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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLVIII JUNE, 1948 WHOLE NO. 422

RED LETTER DAYS OF 1948

Two prominent days should be marked on your calendars, these are November 26 and 27. They mark the date of the 1948 convention, with headquarters at the Claypool Hotel in downtown Indianapolis. The hotel is only three blocks from the Union Station and one block south of the Bus Terminal. There just could not be a more convenient location arrangement. Everyone knows that our conventions are unsurpassed. Have you ever wondered why this is so? Here is part of the secret. Approximately 10% of the membership is in some way involved in the planning for this significant meeting. These members are spending time and an abundance of good thinking to make the 1948 convention at least equal to the excellent conventions of the past. Be assured, it is not easy to maintain the high standards of our programs. At this time I wish to promise you that the Indianapolis members and your 1948 officers are doing their very best to arrange a convention which will offer visitors hospitality, fellowship, inspiration and professional information of top-notch quality.

Many times visitors have expressed surprise about our being able to bring together so many outstanding speakers and experts in their field at one convention. In part this is due to the reputation which our unique organization enjoys, and in part it is the result of unceasing effort made by officers and section chairmen.

Let me remind you that our program is geared to thrill young teachers, so tell them about our convention, invite them to come, or better still, ask them to join the group from your community. They need the wholesome influence of CASMT and we need their participation in our work.

J. E. POTZGER, *President*,
Butler University,
Indianapolis, Indiana

HOMER W. LeSOURD

JULY 27, 1875–MARCH 15, 1948

Mr. Homer W. LeSourd became our physics editor in January 1930 and wrote his last article for us in January 1948, "A Sermonette" a rare bit of advice to the teacher of science.

After graduation from the high school at Bellefontaine, Ohio, he entered Ohio Wesleyan University and graduated in 1898. He then taught for two years in the Delaware, Ohio, High School. Next he went to Harvard University where he received the M.A. degree in 1901. After a year as a physics assistant at Harvard he taught science for one year at Pomfret, Connecticut, then went to Milton Academy

in 1903. Here he served as science teacher and head of the science department until 1945. One year of this time, 1940–41, he spent in Honolulu as a teacher of science in the Punahou School. On return he would probably have retired but Milton again called him to take up the important work of the Academy in preparing the boys for war service and keeping watch on the Atlantic Coast. Much of the time while at Milton he also taught classes in the teaching of physics and general science at Harvard University. After retirement he could not keep away from school but spent a year at Harvard where he put the Optics Laboratory in better shape for conduct of the courses.

Few teachers of science have done better work or have had a greater influence over the students. But he did much more than teach. Almost every movement in New England for the improvement of science teaching for almost fifty years profited by his active assistance. He has been foremost in the Eastern Association of Physics Teachers, serving on many committees and as secretary and as President, a member of the National Association for Research in Science Teaching, a charter member of the American Association of Physics Teachers, and for eighteen years a member of the Central Association of Science and Mathematics Teachers and Physics Editor for SCHOOL SCIENCE AND MATHEMATICS.

A great man and a beloved teacher has completed his labor but his teaching influence will go on.

GLEN W. WARNER

DR. W. M. INGRAM AWARDED RESEARCH FELLOWSHIP

Dr. William Marcus Ingram, professor of biological sciences at Mills College, is one of three scientists just awarded 1948 summer research fellowships at the Edmund Niles Huyck natural history preserve in the Helderbery Mountains outside of Albany, New York.

In his research this summer Dr. Ingram will work on certain fresh water clams that are parasitic in their larval stages on game fish.

The fellowships at this privately endowed ecological research station were open to ecologists in both America and Europe.

On his first Huyck fellowship in 1940, Dr. Ingram made an intensive study of food of fresh water mammals and has published a number of papers on these studies.

Sharing 1948 honors with Dr. Ingram are Dr. William Dreyer, University of Cincinnati, and Dr. Sherman C. Bishop of Rochester University in New York.

Dr. Ingram has been at Mills College since 1941. He received his B.A. from Pomona College, an M.A. from the University of Hawaii, and his Ph.D. degree from Cornell University.

There is no dignity quite so impressive, and no independence quite so important, as living within your means.

—CALVIN COOLIDGE

WORTH-WHILE PROJECTS IN SCIENCE

O. J. WALRATH
Senior High School, Bloomfield, N. J.

Some months ago SCHOOL SCIENCE AND MATHEMATICS published an article of mine entitled "An Experiment in Adolescent Ingenuity." At that time, I promised to describe some of the projects in more detail. That is the purpose of this article.

Possibly I should call this "An Experiment in Teacher Ingenuity," because I feel that too many teachers consider that costly apparatus is necessary. This belief is far from true. In fact, some of the finest demonstrations I have ever seen were carried out with common things around the home or with materials salvaged from the junk pile.

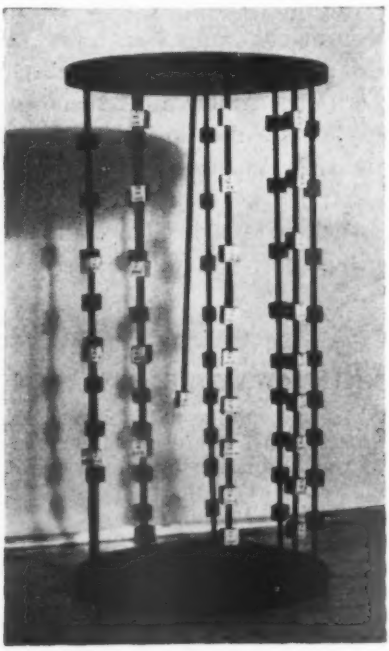

FIG. 1. The periodic arrangement of the elements.
Photo by Art Zimmerman.

You might find it interesting to try the experiment of handing a pupil a few pieces of wood, four or five nails, some screws, and a few feet of insulated copper wire. Tell him to make a simple motor. Possibly, he will add a small spool and a belt for attachment to the wheel of a simple machine. At any rate, he may surprise you.

It may be that you will want a telegraph key and sounder. In this

case, give him a tin can, some pieces of wood, a few screws, a couple of nails, some small pieces of hard rubber and some insulated copper wire. Don't be too upset if he comes in some day with not only the key and sounder but also an ingenious relay. You can never tell what some of these youngsters will do.

Model—Periodic Arrangement of the Elements

Many of the projects will turn out to be excellent teaching aids. If you want a fine model to show the periodic arrangement of the 96 elements one of your students who is handy with tools can do the job for you. All that is needed are two flat circular pieces of board

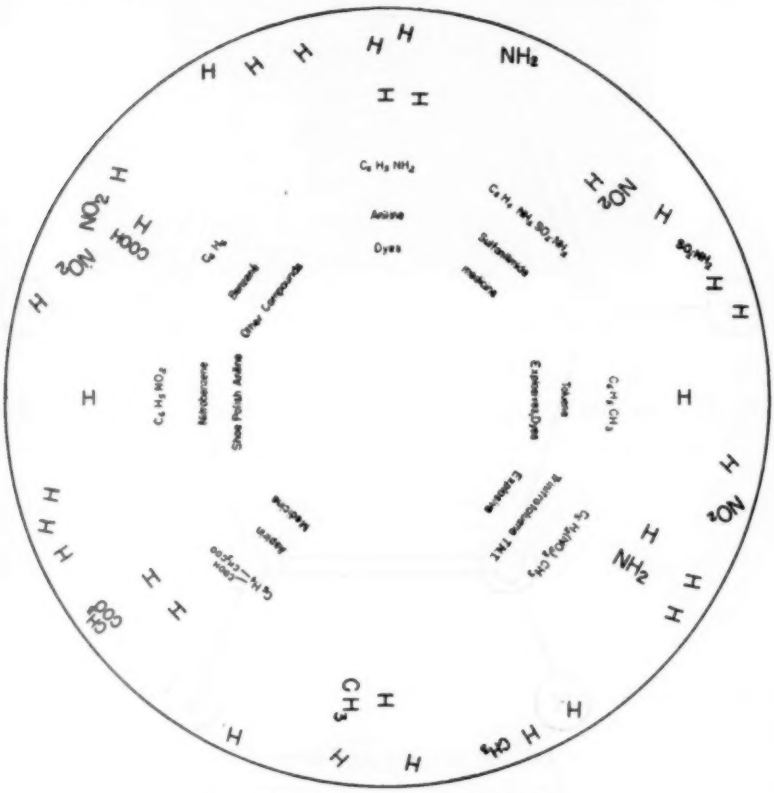

Fig. 2A. Benzene and derivatives.

about a foot in diameter and $\frac{1}{4}$" thick, eight two and a half foot dowels, a one foot dowel, 96 wooden cubes (three-quarter inch and bored to fit the dowels tightly), an auger and some paint and varnish. The accompanying picture shows clearly how to put it together. See Fig. 1.

Benzene Derivatives

A splendid teaching aid in the form of a chart can easily be made

from a piece of stiff white card-board two feet square, a circular piece of card-board one and a half feet in diameter, and a cotter-pin. The accompanying diagrams will show how to prepare each piece of card-board. Be sure to space carefully the H atoms and groups, the uses, formulae and names on the circular board. Note the cut-out squares and rectangles on the square board. The two boards are held together by a cotter-pin through the exact center of each. When the

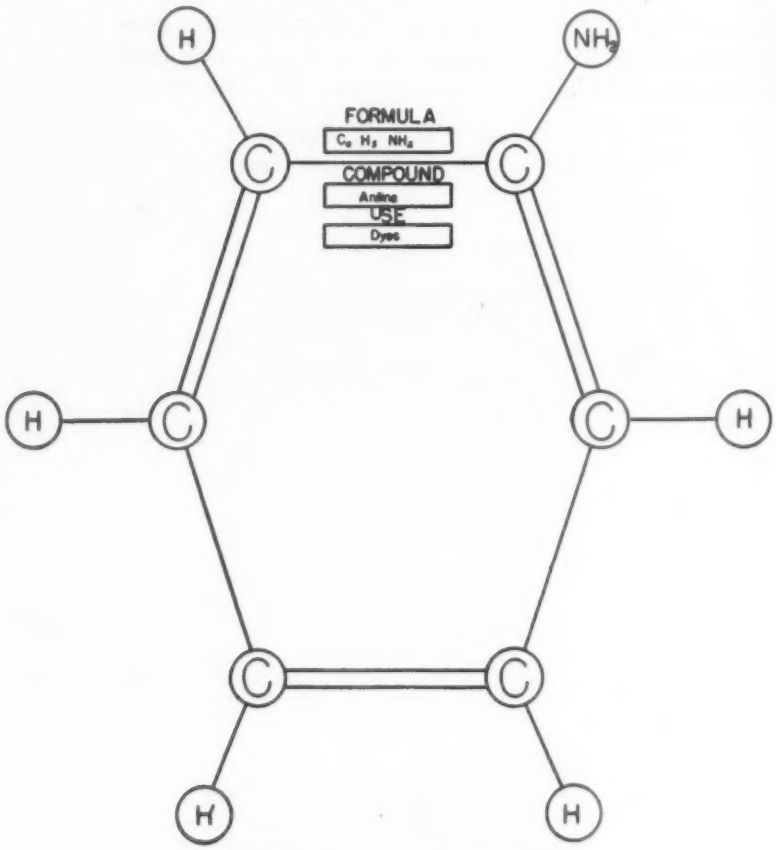

FIG. 2B. Benzene and derivatives.

circular board is rotated, you can show the structural formulae of many derivatives of benzene with their common names and uses.

A CHEMICAL BALANCE

Students are often in a quandary as to how to make a chemical balance for their home laboratories. In the February 1933 issue of the *Journal of Chemical Education*, the author of this article gave very explicit directions for making a home-made balance. We have had

many of these made and they have proved very satisfactory. In some cases, by selecting different metals from those suggested in the article, the students have improved upon the same. One youngster presented an all aluminum balance. It was a master-piece of craftsmanship. How these youngsters surprise you!

FIG. 3. Balance made by a girl in chemistry.

MODEL STEAM TURBINE

A simple steam turbine can easily be made from a tin box, a tin can, a small evaporated milk can, an empty shoe polish box, a short

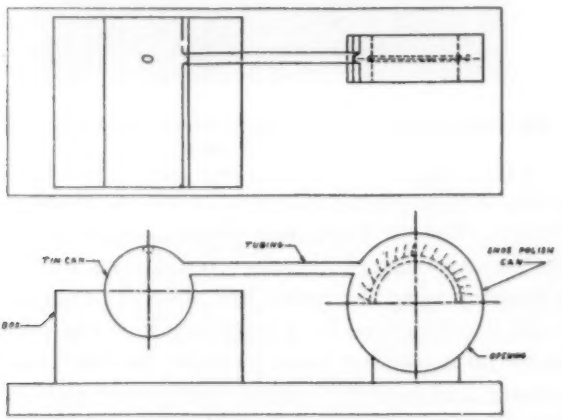

FIG. 4. Steam turbine.

length of copper tubing, some solder, and a 4-inch nail. For the tin can, select one containing fruit juice. Make a $\frac{1}{4}$" hole in its side and

empty. Ninety degrees away from the original hole make another hole just large enough for the end of the copper tubing, which should be soldered in place. Find a cork which will snuggly fit the larger opening and you have the boiler. By carefully cutting two sides of the tin box you have a resting place for the boiler and a space for a small burner to heat the water.

To get the wheel, and jacket, we use a pair of tinner's shears and cut an evaporated milk can in such a way that we have one end and a little more than $\frac{1}{4}''$ of the side. By carefully cutting the side at right angles to the flat end and then bending these little sections, we have our wheel with vanes. This wheel is placed in an empty shoe polish box and a nail is run through the exact center of both sides of the

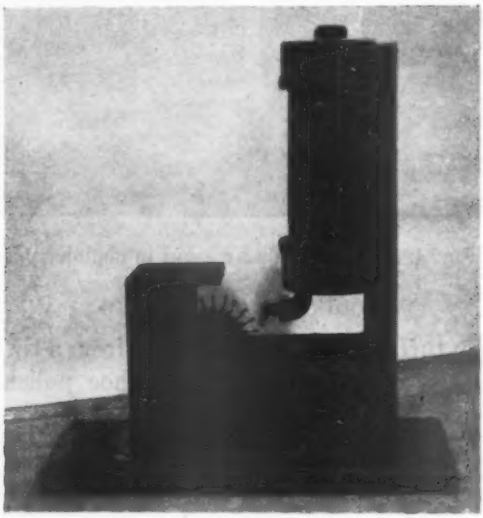

FIG. 5. The transformation of chemical energy to mechanical energy. Photo by Art Zimmerman.

shoe polish box and also the center of the wheel. Make sure the latter can turn freely. Make a small hole large enough to tightly insert a copper tube in one edge of the shoe polish box and a smaller one opposite it to carry away the water and allow for expansion. The shoe polish box can be supported by a small block or the whole apparatus may be placed on a wooden base. Remove the cork from the boiler, add some water and heat to boiling. The steam passes through the copper tubing (you can use rubber), hits the blades on the wheel and this begins to spin.

TRANSFORMATION OF ENERGY

To show the transformation of chemical energy into mechanical

energy a simple apparatus may be made from a two inch piece of iron pipe threaded at both ends, 2 flat end caps, a wheel made similarly to the one in the turbine, and a short iron or other metal tube, with wood to make a support for the pipe and the wheel. In this case, no jacket is needed for the wheel although a 4 inch nail should pass through its center. The ends of the nail rest on wooden supports with small grooves to allow it to turn. One cap is bored and threaded for the insertion of a $\frac{1}{4}''$ plug. Through this opening the chemicals may be inserted. About two inches from the bottom a small hole should be drilled in the side of the pipe and a tube should lead from this outward and down to a short distance from the vanes.

When the apparatus is assembled (shown in the picture), the plug

FIG. 6. A section through a hydra. Photo by Art Zimmerman.

is removed and with the aid of a funnel a strong solution of sodium bicarbonate is added. A strong solution of tartaric acid (cream of tartar may be used) is now poured in and the plug immediately inserted. As the gas is produced it passes out through the tube and against the vanes turning the wheel and our energy has been transformed from chemical to mechanical.

BIOLOGY MODELS

Many biology teachers would be pleased to have fairly large models of the hydra, paramoecium, amoeba, the digestive system and a section of the heart and many others too numerous to mention. Plaster of Paris can easily be molded into the shape desired. We use varnished boards for a support and the model may be glued to the

board or even nailed while still plastic. After the mold has set it can be painted to suit the maker's fancy. These models may be hung and make an excellent display. We have tried modelling clay but this does not harden well and also is not easily colored

Since we have about 800 projects turned in every year, it is obvious that I can describe but a few. We emphasize originality and self-reliance. We have found the project method to be very stimulating and advise others to try the idea. We have had many visitors see the finished products (many of these are chemists, as we are in the center of the greatest chemical industries in the country) and they all acknowledge that they are flabbergasted by the ingenuity of the youngsters.

THE GALESBURG WORKSHOP

Leaders of teacher training in mathematics and representatives of business and industry will participate in the second annual University of Illinois Mathematics Institute and Workshop to be held on the campus of the Galesburg Undergraduate Division, June 28 to July 2.

The "Workshop" is intended for secondary teachers of mathematics in the state and will be directed by Dr. Daniel W. Snader, chairman of the division of mathematics at Galesburg.

Inaugurated last year as one of few such clinics in the country, the five-day program will include lectures, discussions, and group study. It is expected the "Workshop" will attract more than 100 Illinois junior and senior high school mathematics instructors to Galesburg.

Representatives of the Goodyear Tire and Rubber Company, Hamilton Watch Company, Wright Automatic Machinery Company, and Monroe Calculating Machine Company will take part in industrial sections of the "Workshop."

Visiting lecturers will include the following well-known educators:

John R. Clark, professor of mathematical education, Columbia university, New York; Willard B. Spalding, dean of the College of Education, University of Illinois, Urbana; Robert B. Browne, director of University Extension, University of Illinois; H. R. Brahana, chairman of the mathematics department, University of Illinois; Miss Martha Hildebrandt, head of the mathematics department, Proviso Township high school, Maywood, Ill.; and John F. Schacht, chairman of mathematics, Bixley high school, Columbus, Ohio.

Sponsored by the Division of University Extension, the University Council on Teacher Education, and the Galesburg Undergraduate Division, the "Workshop" will have special sections given over to mathematics as applied to research and design, engineering, business, and industry.

Special study groups are being planned for the following:

Psychological approach to the teaching of arithmetic, vitalized instruction in mathematics through the use of instruments, instructional aids in the teaching of mathematics, psychological approach to the teaching of algebra, and a seminar on the problems in teaching of high school geometry.

According to Director Snader, the program is being planned "to provide teachers in Illinois junior and senior high schools with the necessary facilities for collecting and organizing practical applications of mathematics which can be used to vitalize classroom instruction.

Dr. Snader believes the "Workshop" can assist in providing practical materials from business and industry to better prepare teachers of mathematics in the state.

MEASUREMENT IN SCIENCE

KENNETH E. ANDERSON

Teachers College High School, Iowa State Teachers College, Cedar Falls, Iowa

Aristotle maintained that velocity of falling objects differed according to their weight. This is not true. The velocity of a falling piece of lead and that of a piece of wood are equal. Thus began the doubtings of Galileo in the Aristotelian physics. With Galileo began the quantitative conquest of nature which developed into the mechanics of Galileo and Newton. Gradually this concept of mechanics expanded into the science of physics with extensions to elasticity, hydrodynamics, electricity, and heat. Later Lavoisier, using the discoveries of Priestly and Cavendish, explained the true nature of burning, in quantitative terms. Lavoisier thus linked chemistry with the principles of mechanics. Dalton, using the work of Lavoisier, brought the ancient atomic theory of the Greeks to the status of an accepted theory. Physics thus expanded into the world of chemistry.

At the end of the eighteenth century it was thought that science could reduce the organic world to the laws of the physical world. So there arose a battle of mechanism versus vitalism. The proponents of the latter felt that organic materials could not be synthesized in the laboratory. The experiments of Galvani, in which he found that the nerve of a frog produced an electric current; the experiment of Wollaston in 1801 showed that the current from the nerve was like that from a voltaic cell; the preparation of fructose and glucose by Fisher; the cell theory of Schleiden and Swann—all these experiments and discoveries led to the fall of the organic world to the concepts of Newton.

With the advent of behaviorism in 1910, we find Fechner bringing the quantitative and experimental spirit of physics to the study of psychology. In 1834 Weber made the first quantitative uniformity in psychology, "that discriminations between stimuli depend upon the relative magnitude of their differences, not upon their absolute differences."[1] Others like Fullerton, Cattell, and Thorndike followed the work of Fechner by applying mathematics and physics to psychology.

Along with the expansion of physics into psychology, we find physics entering into the field of organic forms. The work of Lamarck, Spencer, and especially that of Darwin and Galton, marked the advent of a new method of studying human nature. To quote from Smith: "Whatever an organism had been, whatever it had come to be, and whatever it was destined to be in the future, was written in the environmental changes, past, present, and yet to be. For the first

[1] B. Othanel Smith, *Logical Aspects of Educational Measurement*, p. 19.

time the evidence and vigorous methods of science supported the conclusion that mind was capable of reduction to the level of the same materials of Newtonian mechanics and subject to the same formal methods of investigation."[2]

Thus we have found that during the period from Galileo through the nineteenth century, the foundations were laid for the quantitative conquest of nature. We have learned that the events of nature are due to the mechanical forces of nature, subject to law and order, and subject to measurement and mathematical treatment. In the pages that follow I will attempt to show that measurement is the basic and principal tool of science.

Without measurement as we know it today, science would still be groping in the realm of half-truths as it did in the medieval days. Science in the middle ages was Aristotelian in nature, consisting largely of enumeration and classification. Enumeration is dependent on numbers as is measurement. Enumeration requires that we classify objects, but not as to length, color, or density. The objects must be nearly alike so that we might call them all balls. We may have handballs, basketballs, and baseballs, all of different diameters, but they would all be balls as far as classification is concerned. When we enumerate them we may count fifty balls. Enumeration, therefore, does not consider the variation of the balls in diameter or surface area, but simply answers the question how many.

In measurement we are interested in how much more or how much less of a certain property of matter. It was thus that science had to turn from the qualitative aspects to the quantitative aspects. We became interested not in the fact that iron expands when heated, but how much it expands with a certain temperature increase. Modern science, therefore, attempts to reduce phenomena into their elements and to describe these elements in a quantitative manner. A classic example is that of Galileo's where he reduced the phenomena of falling bodies into the elements of time, mass, acceleration, and velocity. By measuring only time and distance, Galileo was able to formulate his laws and conclude that all objects regardless of weight undergo the same uniform acceleration of thirty-two feet per second per second or nine hundred and eighty centimeters per second per second.

In enumeration or counting, there is a limitation that only discrete groups may be counted, or that there must be separate objects, as balls. They must all be balls or possess a constant character, that is be classifiable into a group. Whether a scientist counts the balls or an untrained student, the results will be largely the same. The order of counting matters not at all, for again the results will be the same. In actual measurement we are not dealing with a discrete series, but

[2] *Ibid.*, p. 25.

with a continuous increase or decrease of a property, or with different amounts of a continuous property as weight. In other words, measurement answers the question how much.

Measurement may be intensive or extensive. When Cavendish devised his procedure of measuring resistance to the flow of electric current, he compared the shocks he received from different wires connected to a source of current. He was able only to conclude that the one producing the greatest shock had the least resistance. He couldn't say that silver of the same length and thickness had half the resistance of copper. He was measuring only in the sense that different degrees of the quality were arranged in a series from high resistance to low resistance.

The hardness scale of ten is an asymmetrical and transitive series, for we can say:

> Diamond is harder than steel,
> steel is harder than talc, and
> therefore, diamond is harder than talc.

We are not able to say that diamond is twice as hard as talc. Hardness, temperature, density, and intelligence are non-additive. Therefore the questions of how much and how many times are meaningless when we are measuring intensive qualities.

In measurement we must manipulate a physical instrument, and record our readings as we do from a meter stick in measuring length. Take the previous example of Cavendish with wire resistances, in which he was evaluating resistance in terms of his direct experience with electricity. When we use a resistance box or a Wheatstone bridge we are no longer dealing with property, but with its effect. We make our evaluation by means of the instrument. Instruments aid man in detecting and describing, and the more instruments of this type we can devise, the more exact our knowledge will be. An instrument must be valid and reliable. Thus if we are measuring current, we should not use a resistance box, for this is not a valid use of the box. The instrument is not measuring what it purports to measure. An ammeter is designed to measure current, and if it does so consistently, it is a reliable instrument.

Instruments are of two classes. The first class such as the telescope, increases the power of our senses. Meter sticks and voltmeters are examples of the second class, for they enable us to give more exact quantitative descriptions of properties. In measurement we are more concerned with the latter type.

There must be several broad understandings behind the use of an instrument that measures a particular property. Thus the ammeter, which measures the amount of current flowing in a wire, must have a

shunt and be placed in series with the circuit. The laws of magnetism; the production of lines of force about a wire carrying an electric current; the definition of an ampere as that amount of current that will deposit so much silver in one second; the calibration of the ammeter against this standard or definition—all these concepts lie behind the proper use of the instrument.

Measurement in a strict sense can take place only if the property is capable of being arranged in an asymmetrical transitive series as is the case with the scale of hardness, and if the following minimum requirements of addition are met:

If 2 volts + 5 volts = 7 volts, then
5 volts + 2 volts = 7 volts.

If 2 volts = 2 volts, then
2 volts + 1 volt is greater than 2 volts.

If 3 volts = 3 volts, and 6 volts = 6 volts, then
3 volts + 6 volts = 3 volts + 6 volts.

If (3 volts + 4 volts) + 6 volts = 3 volts + (4 volts + 6 volts).

Thus we find that length, time, area, angles, electric current—are all capable of meeting the conditions described above. In other words, they are fundamental units capable of addition.

Measurement in science exists for the sole purpose of discovering the numerical relationships which exist between the physical properties. In the words of Cohen and Nagel, "Science through measurement seeks more and more general invariant laws of complicated phenomena."[3]

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Smith, B. Othanel, *Logical Aspects of Educational Measurement*, New York, Columbia University Press, 1938.

[3] Morris R. Cohen and Ernest Nagel, *An Introduction to Logic and the Scientific Method*, p. 381.

FIFTY-MILLION-YEAR-OLD FOSSILS BROUGHT TO U. S. NATIONAL MUSEUM

Two 50-million-year-old fossil skulls of lemuroid animals, which occupy a branch near the bottom of man's family tree, are among the specimens brought back from Wyoming by Dr. Charles L. Gazin of the U. S. National Museum. These animals, known to zoologists as Notharctus, have as their nearest surviving kin the nocturnal tree-dwelling lemurs of Madagascar.

The skulls are about three inches long, or about the size of the skull of a small cat. The eye-sockets, which are directed almost straight forward, are relatively quite large, indicating that these animals also were night-prowlers.

MEANING OF "STRAIGHT LINE" AND "LENGTH" IN PHYSICS AND GEOMETRY

AUSTIN J. O'LEARY
The City College of New York, New York 10, N. Y.

It is my purpose to discuss the meaning of a straight line and the meaning of length from the two points of view of physics and Euclidean geometry in the hope of contributing something beyond what may be found elsewhere.

POINT OF VIEW OF PHYSICS

Position of bodies relative to one another and *extension* of bodies are perceived intuitively; we speak of bodies as having position and extension in "space." The physical quantity *length* or *distance* is the quantitative measure of extension in one dimension. It is defined by the operation of measuring length, which operation includes the method of constructing measuring sticks as well as the method of using them. Let us see what is involved in the definition.

A plane and a straight line, in the space of measuring sticks, are defined by the lapping process used in perfecting plane surfaces and straightedges. Completeness of contact between two plane surfaces in different orientations relative to each other, and between a straightedge and plane surface, is commonly tested by interference methods. To construct a measuring stick, we mark off adjoining segments or divisions along a straightedge by means of a divider in the familiar manner of geometric construction. Superposition of the divider on each division, one after another, is taken to define a state of equality between the divider and each division, respectively, within certain limitations to be investigated for the operation. Now, how do the divisions on one straightedge compare with those on another straightedge marked off with the same divider? Superimposing any one such edge on any other, we find that any division on the one edge can be made to coincide with any division on the other edge, independently of position in space and materials of which the divider and straightedges may be composed; in other words, there is the same state of equality between any two divisions as between the divider and each division, respectively. This empirical finding, which is so familiar as to be almost an unconscious part of experience, is the basis for the definition of relative length as follows. Each division is taken to have a length of 1 unit (a standard unit will be introduced presently). The length between any two markings on one of the straightedges is the number of divisions or units of length contained therein; addition of segments of length is here indicated and, conversely, subtraction. A

subdivision of a unit, say a fractional part $1/n$, is a segment of length such that n of these segments add up to 1 unit; precise division of a segment into any number of equal parts has been made easy through perfection of the micrometer screw. Finally, the length of a rod is the number of units of length plus fractions of a unit between its end points as determined by superimposing the measuring stick on the rod and observing coincidences between the end points and the graduations on the measuring stick (in this definition, we recognize no incommensurable case like that in geometry); similarly, for the distance between any two given points on a body. A length greater than that of the measuring stick is, of course, measured in sections. Length is an *extensive* quantity by virtue of the way in which we add, subtract, multiply and divide segments. A good example of these operations is the construction and use of Johansson blocks.

We soon learn that the relative lengths of rods and measuring sticks depend both on their respective thermal states and on their respective states of stretch or compression. We see the need to define an invariable unit of length. Furthermore, we wish to make measurements of length commensurable throughout the world. Accordingly, the distance, at 0°C. and standard pressure, between the two transverse ruled lines on the International Meter (a chosen standard body) is taken as a standard magnitude of length. Unit length is defined by assigning a particular value to the standard magnitude; the value assigned to it is 1 m≡100 cm≡0.001 km., and so forth. The primary quantity length is employed in the definition of all other quantities, whether primary or secondary, and since it enters into the definition of temperature and pressure, we arrive at a final definition of length, including a standard magnitude, only by a method of successive approximation. Also, see Lenzen (1).

Precision in the measurement of length depends on three main factors: (i) precision of the graduations on the measuring stick relative to one another and to the standard; (ii) control of temperature and stress affecting the length of the measuring stick; (iii) accuracy with which coincidences are determined, or what is about the same thing, the accuracy with which fractions of a division are estimated, or measured with the aid of a vernier. No matter how carefully length may be measured, a limitation is imposed on the meaning of any given length by the limitation in fineness with which the end points are marked. For example, it would be meaningless to express one's height to a thousandth of an inch; the distance from head to foot is not that definite. Likewise, the finite widths of the two parallel marks on the International Meter impose some indefiniteness, however small, on the standard magnitude of length in addition to that arising

from the finite margin of error with which the specified conditions of temperature and pressure may be reproduced from one time to another. A measured value of length is always a rational number of units, the number of significant figures being judged from the conditions of measurement; a mean value obtained from repeated measurements is commonly appended by some precision index such as *probable error*. Whenever we specify a particular length by an irrational number, say π units, $\sqrt{2}$ units or $\sqrt{3}$ units, we mean simply the best rational approximation to π, $\sqrt{2}$ or $\sqrt{3}$, appropriate to the given circumstances of construction or measurement.

Extension of the definition of length to curved segments is typified by the use of a graduated wheel known as the *circumferentor* or *tire-circle* which is rolled along the path whose length is to be measured. To be sure, this device is not widely used, but its graduations illustrate nicely the operational meaning of length along a curve; metric graduations around the wheel, for example, are made to agree with those on the meterstick when the tire-circle is rolled along the meterstick. Lengths along curves may also be measured with a flexible tape provided there is no appreciable change in length of the tape when it is bent; it would be possible to detect any such change by means of a tire-circle. The circumference of a circle is usually obtained from a measurement of its diameter, and similarly for other regular curves of known geometrical properties. Geometry of the circle enters also into the measurement of angles. The method of constructing protractors and measuring the size of angles is based on the proposition that, for any given angle, the ratio of subtended arc to the corresponding circumference depends only on the angle. By definition, an angle subtending an arc equal to $n/360$th of the corresponding circumference is *an angle of n degrees*, where, for any given angle, n is a rational number obtained either by superimposing a protractor on the angle or by some equivalent operation. The complete self-consistency of measurements involving properties of the circle verifies the properties on which the measurements are based. In this connection, we may recall that abstract geometry, and eventually trigonometry, originally grew out of the use of an empirical geometry in mensuration and surveying. Now that geometry and trigonometry have become so highly developed in their own right, their results are taken over into physics, but always on an empirical and therefore provisional basis.

The definition of a straight line and of length is extended in the triangulation law wherein the path of a ray of light in a vacuum or in a uniform body of air is taken to be a straight line. It is a law to the extent to which it has been tested in surveying. The validity of extrapolating this law to the space of the solar system beyond the reach of

measuring sticks is checked through confirmation of the inverse-square relation in the law of gravitation. Each new physical law extends the definition of the quantities entering into it.

A few words now about *wavelength*. In the case of slowly moving mechanical waves with visible crests and troughs or corresponding features—for example, surface waves on water, transverse waves along a cord, longitudinal waves along a spring—wavelength refers to a distance that is readily discernible. In the abstraction by which we arrive at general equations for the propagation of waves in an elastic medium, as in the development of any physical theory, wavelength and other quantities characterizing the wave motion assume a more abstract meaning; they may, of course, be accurately determined when the equations are applied in particular instances. The step to wavelength of radiation is a further abstraction, far beyond the case of waves in an elastic medium. Precise interference measurements in many different arrangements and with widely different sources of radiation—for example, a sodium flame, a radio transmitter—are all coordinated in terms of a characteristic quantity expressed in units of length and called the *wavelength* of the radiation concerned. Wavelengths are commonly measured with remarkable precision: for example, one interference instrument, the Michelson interferometer, has yielded the relation $1 \text{ m.} = (1{,}553{,}164.13 \pm 0.10)\lambda_s$ where λ_s denotes the wavelength in air at 15°C. and standard pressure of the red line in the cadmium spectrum, the source being at rest with respect to the interferometer.

The operational meaning of length in astronomical space and in the space of atoms has been carefully analyzed by Bridgman (2). The following are examples of laws directly involving length which are applied in these two regions, respectively: (i) triangulation law; law of gravitation; photometric inverse-square law; (ii) Bragg law of X-ray reflection and the laws of crystal structure; Coulomb law. Still another extension in the operational meaning of length, namely, length of a rod with respect to an inertial frame in which the rod is moving, has been fully discussed by writers on relativity theory.

Point of View of Euclidean Geometry

In Hilbert's (3) formulation of Euclidean geometry, the meaning of a straight line and a plane is established by seven axioms of connection and five axioms of order along with the axiom of parallels which distinguishes Euclidean from non-Euclidean geometries; segment, broken line, angle and the various polygons are defined with reference to the straight line; six axioms of congruence are accompanied by a definition of the circle and further definitions relating to angles. Development of an abstract geometry from some such set of

axioms and definitions depends in no way on knowing how to draw a straight line even when it comes to demonstrating the possibilities and impossibilities of construction with a straightedge and transferer of segments or a straightedge and compass. The figures in geometry may be "represented" well enough by figures drawn freehand as long as they are in accord with the axioms, for example, the axiom of parallels in regard to intersections. On the other hand, in actual construction, a straight line is defined by the straightedge; and extension of a straight line to infinity has no operational meaning.

The concept of congruence is an abstraction from, and idealization of, the operations defining length and angular measure in physics. Congruence of segments, of angles and of triangles is taken to be independent of any actual comparison by transposition so that precision of comparison, simultaneity and rays of light simply do not enter into an abstract geometry. Segments of lines are not subject to stress or temperature. A standard magnitude is not needed; any given segment may be used as a standard or unit segment.

In the development of Hilbert, one may easily deduce the following consequences from the algebra of segments based on the axioms of congruence: each of the two perpendicular sides in a right triangle is less than the hypotenuse; any one side in a triangle is less than the sum of the other two sides; a straight segment is less than, or shorter than, any broken line between the same two points; finally (having developed the theory of limits from the Archimedean *axiom of continuity* and having defined magnitude of a curved segment), a straight segment is shorter than any curved segment between the same two points. Thus we may prove purely by deduction that the shortest path between two points is along the straight segment joining them. In contrast, the converse statement, "a straight line is the shortest distance (or shortest line) between two points," is presented in most elementary textbooks either as a definition of a straight line or as an axiom and is used in the proof of a number of propositions. The meaning of "shortest" is taken to be somehow known; it is not in itself defined. The usual elementary treatment is an unsatisfactory mixture of abstract geometry and practical construction with no clear distinction between the two.

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During the first quarter of 1948 farmers received $6.4 billion from farm marketings, 6 per cent more than the first three months of 1947.

BOOK-LENGTH BIOGRAPHIES OF CHEMISTS—ADDENDA

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In the decade 1935–1945 the author endeavored—as a satisfying and profitable avocation—to seek out, to read and to record all *book-length* biographies (individual and collected) in English of physicists and astronomers, mathematicians, chemists, and engineers, metallurgists and industrialists. Subsequently, the titles of pertinent items—obtained by search of (i) the stacks and card catalogs of the important public, university and technical libraries located in the East and Middle West; (ii) the accumulated catalogs of the principal American and British publishers of technical and scientific books; (iii) the lists of offerings, over a decade, of the larger American and British dealers in used and rare technical and scientific works; (iv) much relevant miscellaneous bibliographical reference works: book review journals, printed catalogs of American and British private, public and national libraries, and kindred aids—were published in a series of four bibliographies.[1–4]

Subsequently, reprints of each of these bibliographies were sent to certain major libraries (in both America and Great Britain) which the author had not been able to visit in person, together with a request for the titles of additional items, if any, contained in the library. A limited number of titles of rather obscure items stemmed from these requests. Several others were contributed by interested American and British readers of the published biographies. These titles, together with those of recently published items, comprise a series of four short addenda to appear—it is hoped—in those periodicals containing the corresponding bibliographies.

In consideration of the manner of compilation it is believed that practically all significent English-written book-length biographies of chemists are encompassed in the original bibliography*[3] or in the following addendum. In consequence of this definitive character, these listings are of obvious worth to all professionally interested in the history of chemistry or—more broadly—in the history of science

[1] T. J. Higgins, *Book-length biographies of physicists and astronomers*, Am. J. Phys., 12, 31–39, 234–236 (1944).
[2] T. J. Higgins, *Biographies and collected works of mathematicians*, Am. Math. Monthly, 51, 433–445 (1944).
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[4] T. J. Higgins, *Biographies of engineers, metallurgists and industrialists*, Bull. of Bibliography, 18, 207–210, 235–239 (1946); 19, 10–12, 32 (1947).
* Errata: p. 650, C. A. Brown to C A. Browne; p. 654, W. L. Randall to W. L. Randell; p. 659, W. Jackson to W. Jacks; p. 661, S. G. Crowther to J. G. Crowther; p. 662. Add: C. J. Hylander, *American Scientists* (The Macmillan Co., New York, ed. 2, 1946), 186 pp.

in general. In particular, they can be utilized very usefully in preparing the biographical content of a course of study utilizing the historical approach in the manner delineated by Dr. James B. Conant in his recent well received and widely discussed book, *On Understanding Science: An Historical Approach.*[5]

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MAKING BIG ONES OUT OF LITTLE ONES

The modern trend to make big molecules out of little ones, by the process known as polymerization, is represented in two of this week's crop of 453 new patents. The first, No. 2,436,967, is on a method developed by Gerald J. Leuck of Brooklyn for making synthetic polysaccharides, or higher carbohydrates, out of simple sugars of the glucose class. The sugars, which should be in the anhydrous state, are heated to melting-point in the presence of a catalyst and a substance that will absorb the water given off when two or more of its small molecules are welded into one larger one. Uses of the products are not mentioned, but plastics, adhesives and the like seem possibilities.

LATITUDE DETERMINATION WITHOUT A SEXTANT

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INTRODUCTION

Celestial navigation, even among trained personnel, is commonly regarded as extremely difficult, although the illiterate South Sea Islander, using a water-filled cocoanut shell equipped with cross-hairs, is able to navigate quite successfully over thousands of miles of seaways.

During the recent war, it became apparent that a special type of navigation, here called "survival navigation" was of considerable importance; and numerous special navigational methods, requiring not only few instruments, but a minimum of computation, were developed.

Where rapid determination of latitude is not necessary, and accuracy need only be to the nearest degree, latitude may be determined, in the temperate zones, by use only of a star table, a watch that runs, and some careful observations.

GENERAL THEORY

To an observer in the northern hemisphere, all northern stars appear to revolve counterclockwise about the north celestial pole, whose position is indicated *approximately* by Polaris (the North Star). In middle latitudes, stars close to the celestial pole are visible at all points on their track, but those farther from the pole have a part of their course below the horizon.

From elementary astronomy we know that if the polar distance of a star (90°—declination) is less than the colatitude of the observer (90°—latitude), the track of the star will always be above the horizon. By rearrangement of the data we arrive at the general rule: if the track of a star is always above the horizon, the observer's latitude is less than the declination of that star; and if a part of the track is below the horizon, the observer's latitude is greater than the star's declination.

Thus, using only a star table, a man can determine his approximate latitude after only one night of observation, using no instruments whatsoever, and making no computations. The latitude thus determined will be very much more certain than one based on an estimated altitude of Polaris, but will still leave much to be desired.

SPECIFIC DETERMINATION

Whenever the track of a circumpolar star is partly below the

horizon, the latitude of the observer can be determined, provided the polar distance of the star is known (from star table; or graphically by measuring and bisecting the angular diameter of the track), and the time that the star is below the horizon is measured. Accuracy of this latitude is limited only by that of the data and instrumental determination. On an airless world, using only a standard star table and a good watch, the latitude error might be only a few minutes of arc. On Earth, because of atmospheric refraction, a single determination might be considerably more than a degree in error.

Relations necessary for such a determination are shown in Fig. 1. Here, the observer looks north, toward the celestial pole. About this

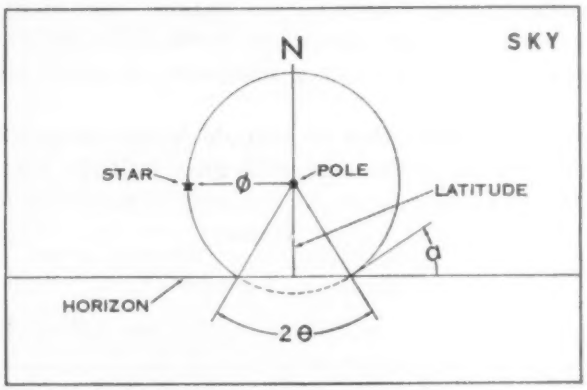

FIG. 1. Geometrical relations of celestial pole, horizon, and star track when the latitude of the observer is greater than the declination of the star.

pole, all visible stars appear to rotate counterclockwise.[1] Because the star tracks are circular, and a complete circuit of 360° is made once each siderial day (23 hours, 56 minutes, 4.1 seconds of mean, or "clock" time), the time during which a star is below the horizon can be expresed as an angle. This is the angle 2θ in Fig. 1, and is computed from:

$$(1) \qquad 2\theta = 360\,\frac{T}{D} \quad \text{or} \quad \theta = 180\,\frac{T}{D}$$

In which:

T = time during which the star is below the horizon.

D = length of siderial day, expressed in units compatible with T.

From plane trigonometry, it should be apparent that the latitude of the observer is the perpendicular distance from the celestial pole to the horizon, expressed in degrees of arc (Fig. 1), and that this meas-

[1] Fath, E. A. *Elements of Astronomy*, New York, 1944, pp. 28–29; Fig. 18.

urement is made along the perpendicular bisector of the horizon chord. This distance is found by simple trigonometry, the hypotenuse of the right triangle being ϕ, the polar distance of the star, and is shown by the formula:

$$\text{Lat.} = \phi \cos \theta \quad \text{or} \quad \text{Lat.} = \phi \cos \frac{180}{D}. \tag{2}$$

This determination could be quite rigorous on an airless world, but gives excessive latitudes in all instances under terrestrial conditions, because atmospheric refraction advances the observed time of rising of a celestial body, and retards the observed time of setting.

Unfortunately for navigators, atmospheric refraction is not strictly constant in its effects, so that no numerically specific correction can be made for it in practice. In most instances, however, the temporal error due to refraction can be determined from Humphreys' formula:[2]

$$t = 2.33\dot{3} \csc a. \tag{3}$$

In which:

t = time between observed rising of celestial body and actual rise.
a = acute angle between track of celestial body and horizon.

This formula is an average of a large number of computations and observations, and may be regarded as a "stable average." Under refractive conditions, θ of (1) and (2) no longer equals $180T/D$ but becomes:

$$\theta = 180 \frac{T+t}{D} \tag{4}$$

and by substituting its value from (3) for t, further becomes

$$\theta = 180 \frac{T+2.33\dot{3} \csc a}{D}. \tag{5}$$

From the geometry of Fig. 1 it should be obvious that $\theta = a$ (theorem of mutually perpendicular sides, etc.), so that (5) may be rewritten as:

$$\theta = 180 \frac{T}{D} + \frac{180 \cdot 2.33\dot{3} \csc \theta}{D} \tag{6}$$

an equation which can be solved either by use of an infinite series and

[2] Humphreys, W. J. *Physics of the Air*, New York, 1940, pp. 465–466.

a lengthy and involved computation; or, and in a relatively few minutes, to the requisite accuracy, by use of successive approximations ("trial and error").

By inspection, we know that the value of θ exceeds $180\ T/D$. Because csc θ increases in value as θ becomes small, the maximum value of θ will be less than:

$$180\frac{T}{D}+\frac{180\cdot 2.333\ \csc 180\frac{T}{D}}{D}. \tag{7}$$

Both of these limiting values can be determined with relative ease by direct computation. Somewhere between them lies the correct answer, which can be determined to any desired accuracy (except 100%) by substituting judiciously chosen intermediate values into (6) until the equation balances.

Latitude is computed by (2), using the value of θ determined above.

Limitations

The theoretical accuracy of this method of determining latitudes is great. The practical accuracy is very much less, due to atmospheric refraction, observer errors, watch error, and the limitations of tables and computing methods. In a very general way, latitudes determined by this method will have a probable error exceeding 30′ of arc (approximately 30 nautical miles), and hence are only slightly more accurate, at best, than those based on an uncorrected Polaris sight.

Conclusion

This "time and track" method of latitude determination is a navigational makeshift, of great value only when a sextant is not available but a watch and star table are. Its field use should be limited to actual emergencies, when no better method can be employed. In the classroom and laboratory, the method appears of definite instructional value.

The number of independent components (that is, bureaus, commissions, etc.) in the Federal Government now totals 2169. The Government now employs 1,994,752 persons, as against the all-time peak reached in 1945 of 3,769,600. Nearly 25,000 persons work in the Federal Government without compensation (not even a dollar a year!).

Within the next five years television will serve 40,000,000 people. Some 12,000,000 sets will be in use, predict television industry leaders.

SCIENTISTS ON POSTAGE STAMPS

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Every one is familiar with the practice of using postage stamps as a means of honoring famous men and events. Nearly every country in the world except Great Britain and her colonies use their stamps in

Fig. 1. First row: *mathematicians*, Abel, Descartes, and Hamilton. Second and third rows: *physicists*, Guericke, Galvani, Onnes, Chaplygin, Roentgen, Pierre and Marie Curie.

this way. This practice furnishes a group project that will be of considerable interest to a high school science club. Unusual and distinctive exhibits can be made by collecting the portraits of scientists and

mounting them in picture frames. Not only will these portraits make excellent exhibits but they can also be used to decorate the walls of the meeting rooms. An example of the possibilities of this pursuit is given in Fig. 1, which shows portraits of three mathematicians and seven physicists.

In many cases the greatest success will be obtained when the members of the school's philatelic club are invited to help with the project. They are familiar with the source of supply and they will know how to mount the stamps properly.

In mounting the stamps each picture frame should be devoted to one topic, such as astronomy and astronomers, or biologists, or physicists. The minimum amount of information that should be listed under each portrait is the name and the dates of birth and death. This can, of course, be expanded to any length that is desired in order to include a biography or a list of important discoveries. If the school has a printing shop, it may be possible to have forms printed which will have a frame for the stamp and printed biographical data. This technique is used with great effect by the Library of Congress.

Postage stamps are identified by the number which they have in the "Standard Postage Stamp Catalogue" which is published by Scott Publications, Inc. In order to designate a particular stamp one must give only the name of the country and the number of the stamp. Since each denomination is listed separately, it is better to give the illustration numbers when one is concerned only with the portraits on the stamps. The latter practice is used in the lists that follow.

Only two astronomers have been commemorated on postage stamps. They are

Copernicus	Poland	A33
Roemer	Denmark	A53

This frame can be completed with the following material.

Astronomial Observatory	Estonia	A17
Astronomical Observatory	Guatamala	A78
North Star and the Big and Little Dippers	Cyrenaica	AP7
Southern Cross	Brazil	A33, A38, SP5
Black Cloud in Orion	Mexico	A154
Total Solar Eclipse	Mexico	A155
Spiral Galaxy in the "Hunting Dogs"	Mexico	A156
Spiral Galaxy NGC 4594	Mexico	AP56
Planetary Nebula in Lyra	Mexico	AP57
Russell Diagrams	Mexico	AP58

The last six stamps were issued by Mexico in Commemoration of the Astrophysics Congress and of the inauguration of an observatory at Tonanzintla, February 17, 1942.

The following biologist and naturalists have been portrayed on postage stamps.

Aubudon	U.S.A.	A333
Bernard	France	SP48
Burbank	U.S.A.	A335
Darwin	Ecuador	A133
Leeuwenhoek	Netherlands	SP78
Linné	Sweden	A59
Long	U.S.A.	A334
Mendel	Danzig	A37
Pasteur	France	A23, SP20
Reed	U.S.A.	A336

It is surprising that so few chemists have been honored on postage stamps. They are:

Berthelot	France	A33
Berzelius	Sweden	A58
Koch	Danzig	A38
Lavater	Switzerland	SP108
Mendelyeev	Russia	A184, A185
Scheele	Sweden	A71

A picture of a chemist at work is shown on the German stamp SP52.

The following inventors have been pictured on postage stamps.

Bell	U.S.A.	A352
	Argentina	SP3
Benz	Germany	A89
Edison	U.S.A.	A392
Howe	U.S.A.	A351
Jacquard	France	A51
McCormick	U.S.A.	A350
Morse	U.S.A.	A349
	Argentina	SP1
	Peru	A173
Whitney	U.S.A.	A348

Of the five mathematicians that have been commemorated on postage stamps three were honored probably because of their philosophical writings.

Abel	Norway	A18
Descartes	France	A78
Hamilton	Irish Free State	A17
Leibnitz	Germany	A57
Zeno	Cyprus	A16

Of all the scientists physicists have been the most frequently honored and of the physicists the Curies, Marie and Pierre, have been most frequently commemorated. The stamps honoring Marie and Pierre Curie were issued in 1938 in commemoration of the 40th anniversary of the discovery of radium. In each case a surtax was charged for the benefit of the International Union for the Control of Cancer. It will be noticed that the picture of Roentgen shown in Fig. 1 has "Fight Cancer" on it.

The following physicists are on postage stamps.

Ampere	France	A60
Bequerel	France	SP156
Bouger	Ecuador	A136
Chaplygin	Russia	A497
Madame Curie	Turkey	SP22
Marie and Pierre Curie	Afghanistan	PT2
Marie and Pierre Curie	Cuba	SP1
Marie and Pierre Curie	France	SP35
Marie and Pierre Curie	Monaco	SP7
Marie and Pierre Curie	Panama	PT1
Eotvos	Hungary	A39
Galileo	Italy	PN3
Galvani	Italy	A176
Gramme	Belgium	A66
Guericke	Germany	A90
Huygens	Netherlands	SP34
Lorentz	Netherlands	SP33
Marconi	Italy	A223
Onnes	Netherlands	SP70
Pacinotti	Italy	A172
Roentgen	Danzig	A39
Tesla	Yugoslavia	A12
Volta	Italy	A84

With few exceptions these lists have been confined to portraits. If one wishes to pursue the hobby further a very interesting display can be made of the Russian explorations of the polar regions. No less than seven sets of stamps have been issued by Russia in celebration of this work. Alternately, one could trace Darwin's famous voyage of the *Beagle* around the world and illustrate the scenes, animals and natives that he described. For example, Ecuador has issued a set of six stamps on the centenary of Darwin's visit to the Galapagos Islands.

Many further possibilities for exhibits are described in a very interesting article by Harold F. Schaeffer.[1] This article contains numerous illustrations and it discusses the various applications of physics that have been portrayed on postage stamps. It might be mentioned that the Scott system of numbering stamps has been changed since this article was written and consequently some of the numbers given there will not agree with recent catalogues.

To anyone who plans to assemble collections that illustrate different phases of applied science, the pamphlet "Subject Matter of Philately" is indispensable.[2]

[1] Harold F. Schaeffer, "Philately for Physicists," *Am. J. Physics* (Am. Phys. Teacher), 6, 21 (1938).
[2] Phebe B. Booth, "Subject Matter of Philately" (The Gossip Printery, Holton, Kansas, 1944).

We shape ourselves, the joy or fear
Of which the coming life is made,
And fill our future atmosphere
With sunshine or with shade.

—JOHN GREENLEAF WHITTIER

ACCELERATED MOTION APPARATUS

H. Clyde Krenerick
3000 N. Maryland Ave., Milwaukee 11, Wis.

The type of apparatus for accelerated motion here shown may be used for four interesting and instructive experiments. It is constructed from two pieces of wood $\frac{3}{4}\times3\times60$ inches with one edge slightly beveled. They are fastened together so as to form a plank $1\frac{1}{2}\times3\times60$ inches with a shallow groove in one edge. The pendulum is the proper length (25 cm.) to make a complete vibration in one second.

No. 1. Laws of Accelerated Motion

The distance the ball rolls down the incline during the first second

The Accelerated Motion Experiment

and during the second second is determined by experiment. From these two distances the acceleration is obtained. The student then discovers for himself the relation between the total distance, the acceleration, and the time. He develops the formula for distance in terms of acceleration and time. This is more instructive than to measure the distance an object falls in half a second and then merely apply the formulas.

To set up the apparatus, place the pendulum support near the upper end of the incline and at such a position that the center of the

bob, when at rest, will be seven or eight centimeters from the center of the groove. The pendulum clamp is adjusted until the bob in its vibration will just miss the edge of the plank.

To operate the experiment, place the ball in the groove and pull the bob aside until it is in contact with the ball. Hold the bob in this position and move the ball to some position up the incline. If now the ball and the bob are released at the same instant and the ball and the bob should just touch in passing, it is evident that the distance between the starting point and the point of contact is the distance the ball rolls during the first second.

To obtain the distance the ball will roll during the first two seconds, move the pendulum support down near the lower end of the plank and adjust its position as before. Determine in the same manner the starting point of the ball so that the ball and the bob will strike at the end of the second complete vibration.

The accuracy of the results will depend largely on holding the bob in the correct position when it is released. With a little experience the ball and the bob can be released at the same instant. It is done by the same movement of finger and thumb on the two hands.

No. 2. Newton's Second Law of Motion

The students have discovered in a previous experiment how to determine, by the parallelogram of forces, the component force of gravity that causes a ball to roll down an incline. (The force producing motion is to the weight of the ball as the height is to the length of the incline.) The acceleration produced by this force acting on the rolling ball can be determined, it was discovered in the previous experiment, by taking twice the distance passed over the first second.

With the end of the plank set at a definite height, 12 inches, measure the length of the incline, and compute the force acting on the ball parallel to the incline. Determine by experiment the distance the ball rolls the first second and compute the acceleration produced. For a second force and the acceleration produced, set the end of the plank at a height of 18 inches and repeat the experiment and computations. From the ratio of the forces and the ratio of the accelerations, the relation can be expressed as a law.

It if is desired to state Newton's Law of Motion as the Law of Momentum instead of the Law of Acceleration, the velocity of the ball at the end of the first second in each trial can be obtained. It was shown in the first experiment on acceleration, that the velocity at the end of the first second is twice the distance passed over the first second.

No. 3. Gravitational and Absolute Units

In this experiment the force causing the ball to roll down the

incline is measured in both gravitational and absolute units, pounds and poundals.

If the ball is weighed in pounds and the motion component of gravity is determined from the length and height of the plank by applying the parallelogram of forces, then the force producing motion is measured in pounds.

To measure the same force in terms of the mass acted upon and the acceleration produced, determine the acceleration by experiment as in the previous experiment. From the mass in pounds and the acceleration in feet per second, per second, compute the force in poundals. ($F = MA$) To become familiar with the dyne measure the mass in grams and the acceleration in centimeters per second, per second.

No. 4. Potential and Kinetic Energy

In this experiment an object (ball) is raised to a certain distance above the table and its potential energy in relation to the table computed. Then it falls or rolls down the incline and its kinetic energy as it strikes the table is determined. (Neglecting friction, an object rolling down an incline may be considered a falling object.)

The potential energy is determined by computing the amount of work necessary to raise the ball from the top of the table to the top of the incline. Measure the weight in pounds and the distance in feet to express the energy in foot-pounds.

Neglecting friction the kinetic energy of the ball as it strikes the table, by falling or rolling down the incline, must be equal to the potential energy that it had when it started. To demonstrate experimentally, determine the acceleration of the ball as in the previous experiment and measure the total distance the ball will roll. The velocity when it strikes is now obtained from the relation or formula, $V^2 = 2AS$. Substitute the weight and the velocity obtained in the formula for kinetic energy (K.E. $= MV^2/64$). With this formula the result is expressed in foot-pounds so that it may be compared with the potential energy. Some percent of error must be expected due to the friction of the ball.

It is the author's experience that any problem that can be formulated from observations or measurements obtained from an experiment in the laboratory is far more interesting and more instructive to the student than one taken from the text. Any law or principle will be more easily comprehended by the student if he can derive it, or apply it, in some experiment individually performed in the laboratory. The four experiments are illustrations of the author's effort to introduce to the student practically all of the fundamental principles of elementary physics.

For the detailed instructions to the student for working these experiments, write to the author for a copy of *Experiential Physics*.

(See advertisement in the February number of SCHOOL SCIENCE.) These instructions are so written that the student can be held responsible for the task without any previous classroom discussion. It is an accepted theory of education that the instructive value of a student activity is largely in proportion to the amount of initiative required on the part of the student.

MATHEMATICS INSTITUTE FOR TEACHERS

DUKE UNIVERSITY, DURHAM, N. C.

AUGUST 9–20, 1948

Director: PROFESSOR W. W. RANKIN, Mathematics, Duke University
Assistant Director: MISS VERYL SCHULT, Washington, D. C.

General Theme—*Mathematics at Work*

Registration 9:00 A.M.–4:00 P.M. Monday, August 9
Some of the important lectures follow:

Monday, Aug. 9, 8:00 P.M. *Dynamic Stability of Guided Missiles* Dr. F. G. Myers, Engineering Division, Glenn L. Martin Co.

Tuesday, Aug. 10, 11:00 A.M. *Palatable Mathematics* Prof. W. W. Rankin, Mathematics, Duke University.

Tuesday, Aug. 10, 6:00 P.M. Banquet. Address: *General Education in a Technical Society* Dr. Dwayne Orton, Educational Director, International Business Machines Corporation, New York.

Wednesday, Aug. 11, 11:00 A.M. *The Non-Academic Student in Mathematics* Miss Mary A. Potter, Former President NCTM and now Vice-President CAS&MT.
A Study of Some of the Parameters Affecting Rocket Performance Dr. C. H. Harry, Engineering Division, Glenn L. Martin Co.

Wednesday, Aug. 11, 8:00 P.M. *Applications of the Exponential Function* Prof. J. W. Cells, Mathematics, North Carolina State College.

Thursday, Aug. 12, 11:00 A.M. *Some Properties and Applications of Plane Curves* Lt. Col. R. C. Yates, Mathematics, U. S. Military Academy, West Point.

Thursday, Aug. 12, 8:00 P.M. *Design and Use of an Infrared Spectrophotometer for the Analysis of Organic Mixtures* Dr. E. J. Martin, General Motors Research Laboratories.

Friday, Aug. 13, 11:00 A.M. *Mathematics at the Proving Grounds* Mr. Kenneth Stonex, General Motors Proving Grounds.

Friday, Aug. 13, 8:00 P.M. *Mathematics in Aeronautics* Admiral Alfred M. Pride, U. S. Navy, Washington, D. C.

Saturday, Aug. 14, 11:00 A.M. *Automatic Digital Computing Machines, Their Present and Future* Dr. E. W. Cannon, Bureau of Standards, Washington, D. C.

Saturday, Aug. 14, 6:30 P.M. *Mathematics Comes into the Laboratory* Mr. Everett S. Lee, General Electric Co., Schenectady.

The program for the following week is just as good. Write Prof. W. W. Rankin, Duke University, Durham, N. C. for full program and expenses. The Study Groups also will be a very important part of the Institute work.

He that respects himself is safe from others; he wears a coat of mail that none can pierce.

—H. W. LONGFELLOW

MATHEMATICS DESIGNED TO SERVE DIFFERING INDIVIDUAL NEEDS

MARGUERITE E. WOLFINGER
East High School, Superior, Wisconsin

With the population of our high schools fast becoming a cross-section of our entire country's population instead of a representation of but a small minority composed of the scholars and thinkers, and with the accelerated demands of our social and economic situations, it is fitting and essential that mathematics, the universal language of the social, economic, industrial, and atomic age into which we have entered, be properly attuned to the rhythm of the times. Now, the minority of our school population are those who will use the sequential mathematics as a vital, moving necessity in the course of their lifetime. The majority will be most vitally affected and influenced by that basic mathematics which functions in the vibrant, practical issues of normal existence. Hence, mathematics courses must aim to give that kind of mathematics to those who avail themselves of its opportunities. It must serve, as well, to help those whose grasp of the essential and basic facts and processes have been unduly retarded by giving them an opportunity to progress and gain security at their own speed and when their development permits of success.

At Superior, Wisconsin effort is being made to meet these individual needs by using a "Double Track" plan in which both the sequential and the practical or applied mathematics are offered. Each student is expected to complete at least one year of mathematics for graduation, in either the ninth or in the twelfth year. A two-year course in "practical" mathematics will be available so that a student may elect the applied mathematics sequence, beginning in the ninth, tenth, or eleventh year. Ordinarily he will be guided to elect this sequence in the eleventh grade. However, if there is a possibility that a slight retardation of development is present, and there is evidence that his eventual interests may lie in the sequential course, he may be encouraged to elect the applied course in his freshman year so that he can later redirect his efforts, if he so desires.

In the development of such a program, many are the aspects which must be considered. First and foremost, are the factors involved in the individual abilities of the students who are participating in the educational activities of our modern society. Some are still of the same calibre as those found in the classical high school and college courses of the early part of the century and will continue to follow the stringent pursuits of the intellectual and of the scientist. Others desire primarily to continue in the field of stern practicality. In the

third great group are those of lesser ability who are in the high schools because the great onrush of advancing civilization has so mechanized our society that there is a retardation of the entrance of youth into the status of social and economic adulthood, and who are merely biding the time until they can find a place for themselves in the less challenging and more humble jobs of the nation and the world. Thus, the three types of mathematics that the high school must provide are found in the sequential courses for the bright and highly intellectual student; the practical, general mathematics courses for the average business man, industrialist, and skilled worker; and the basic, fundamental course which will help those in the unskilled tasks of the social and economic pattern of life, to fulfill those tasks with more efficiency and understanding than they would otherwise be able to attain.

Second, a society whose social structure is moving and changing so rapidly demands that the schools maintain the standards which are essential to support the onward movement of today's world. Herein lies society's challenge to mathematics! Social mathematics requires that each member of society know the common practices of the home and of the consumer; that he understand the principles of banking, governmental support, insurance, savings, and security. Industry, mechanics, and all specialized fields demand that its workers be able to handle the fundamental mathematical computations and principles involved in dealing with their problems. This alone, for the average citizen, without considering the advanced training that the specialized mathematician, engineer. or scientist must undergo to attain his goal, is a problem of paramount importance to mathematics educators of today.

Accepting this challenge of the varying mental and interest abilities of the students in our high schools and the charge of the diverse social and economic agencies of the age, and in keeping with the Second Report of the Commission on Post-War Plans,[1] a two-year General Mathematics Course should be evolved to provide for those students in our high schools who do not plan to continue their work in the field of science or mathematics. It should be a course to be chosen especially by those who plan to terminate their mathematics preparation at the end of either one or two years of study.

The general design of the program should be one of flexibility. By its very nature and unique organization, it should lend itself much more easily to the individual needs and interests of the students. Since it would be more or less of a survey course of mathematics in its applications to modern living, it could be greatly enriched or minimized according to the abilities, needs, or interests of the students

[1] National Council of the Teachers of Mathematics. "The Second Report of the Commission on Post-War Plans" *Mathematics Teacher*, XXXVIII (May 1945). Pp. 205–211.

electing it. In any event, it is organized to stress the applications which the students would be the most likely to meet at the termination of their school careers. At the same time, any student should be able to change his plan and enter the regular sequential course, should he discover that his interests and abilities lean in that direction.

Analysis of the Course of Study should reveal that the first year is a basic course which furnishes the significant meanings, understandings, and processes necessary to the attainment of a feeling of success; and to a sense of security in the handling of important social, industrial ,and commercial situations requiring mathematics. The second year should point toward an expansion and enrichment of the first year's work. True, many of the same topics would be dealt with and the same processes would be used, but they would be used in such a manner as to challenge the student to broaden his interests in the field of applied mathematics; to incite him to display his best effort in order to attain his maximum degree of efficiency; and finally, to increase his feeling of security still further in encountering the problems of the adult world of competition into which he is entering.

Following through this analysis, the important high-light of the second year of this attack upon the problem of providing for a large percentage of our high school population would be the idea of introducing "Special Interest and Computational Workshops" at intervals throughout the year and for a more extended period at the end of the second year program. The term "Workshop" as used in the above reference, designates an organization for informal, but directed research and cooperative effort in the accomplishment of a unified and widespread purpose, and is fundamentally attuned to an educational system that is grounded upon the mechanistic psychology of the modern age. It connotes a working together, a place where each contributes his own share and efforts toward a finished product; a place where individual differences are recognized but where each remains an integral part of the composite unit. In keeping with the psychology of this plan, these Workshops should support a two-fold purpose: First, to afford an opportunity for the more advanced students in the course to investigate fields of special interest to them; and secondly, to provide an adequate maintenance program during which the mechanics and understandings of mathematics can be clarified for the slow-normal group.

In the "Special Interest and Computational Workshop" plan for the applied mathematics course there is provision for the strengthening of weakness in the individual student's understanding of and facility in the use of the various fundamental mathematical processes. To approach the Workshop intelligently and to assure its success as

a medium for providing for individual differences, it will be necessary to diagnose the abilities and difficulties which each member of the class possesses. To do this, a diagnostic test covering the various mathematical fundamentals and understandings will prove valuable. Such a test will assist the teacher in instituting a remedial program for students showing weaknesses in the various phases of mathematics. If the text is keyed to the instructional pages of the basic text, as well as to the Check List,[2] the student can readily review the foundation material himself with occasional teacher assistance and guidance. Then, by furnishing him with comparable exercises and practice problems and by retesting each type of understanding or process, he can be guided step by step toward greater clarity of conception and toward an increased skill of performance.

Naturally, some students will require much stress upon remedial work and development, while others will require little. In the latter case, interest must be maintained, if the Course in Applied Mathematics is to be efficient and is to fulfill its two-fold purpose. Here is where provision is made for environmental, as well as for psychological differences. Should the locale be fundamentally rural, the problems revolving around the home and agricultural pursuits will undoubtedly be of major importance in the minds of the community and be a prime requisite for a successful adult. Seed and feed mixtures; feeding and production records for the care of livestock; ratios and proportions; gearing and power formulas in handling machines; volumes and areas in providing for crop storage and crop rotations; and canning and cooking ratios in the increasing and decreasing of recipes which is so often necessary in the always uncertain demands upon the farmwife; all use the fundamental mathematical principles of equations, formulas, geometric constructions, measurements—direct and indirect, graphs, and the four fundamental processes involving whole numbers, fractions, and decimals.

Or, perhaps industry claims the topmost rank of interest. Here, mechanics, the shop electrical applications, radio,—all present vast fields for special investigation and study. The special formulas involved in each field can often be traced back to simple well-known relationships; equations will be found essential and helpful; scale drawings are practically indispensable; accuracy and precision in measurement and in the use of various measuring instruments are "a must"; ability to compile information and production facts statistically and graphically becomes of prime importance; and the fundamental processes involving whole numbers, fractions, and decimals

[2] National Council of the Teachers of Mathematics. "The Second Report of the Commission on Post-War Plans." *Mathematics Teacher*, XXXVIII (May 1945). Pp. 197–198.

represent the veritable backbone of the entire structure. What a source for special interest investigation!

Aviation, art, music, commerce, government, transportation, scientific research, medicine are vast storehouses for special interest workshop investigations which various students may choose to launch as their particular contribution to the entire workshop endeavor.

Much of this workshop activity may be accomplished by the organization of small groups, or the individual may work alone, as soon as he proves that he is proficient in the basic principles and no longer requires the more routine supervision of the teacher. Then, as each student completes his project, cooperative sharing of the results of the composite group will broaden the ken of each individual and add zest and a vitality to the whole general mathematics course.

To the ingenious teacher lack of library material need offer but a slight deterrent to the workshop investigation and research. A few selected single texts on specialization mathematics in the shop, in agriculture, or in the trades plus commercial and trade journals and the aviation and scientific magazines so popular with the boys, or cookbooks, patterns, and sewing books for the girls, will make it possible for students and teacher to supply their own reference shelf. Excursions to the shops, industrial plants, airports, city hall, and many other vital sources can be arranged for small groups or for individual students so that first hand problems and information may be gained through the interview method and through observation.

Reports of these excursions and interviews may be shared with the entire workshop group through many interesting media, such as the panel discussion, quiz programs, student-prepared slides, or debate sessions, as well as the usual cut and dried method of the oral or written reports. Sets of typical problems can and should be presented for class solution by each group of investigators and through guidance the entire class can be led to a realization of the interrelationship through mathematics of all business and industry. For example, the formulas involving the simple multiplication process in which $A = bh$ of geometry and the construction, agricultural, and engineering field parallels $C = np$ of the consumer and production area of business, or $E = IR$ of the electrical trades, or $d = rt$ of aviation and transportation, are but suggestive of the many avenues open to the teacher of applied mathematics to revitalize the simple basic processes for the slower students by utilizing the findings of other class members.

A unit of this sort, perhaps more than any other must be subjected to continual scrutiny and frequent redirection, so that its potency may not be dissipated by wide deviations from its original purpose.

Consequently, keen evaluation is essential. It must be remembered in this connection that evaluation is an active, living, searching part of any educational program,—one which reaches beyond facts and fields of application into the understandings and psychological growths of the individual. Hence, it cannot be dependent upon one or more somewhat mechanical measuring instruments in the form of tests, but must be a continuous process of analysis and adjustment on the part of both pupils and teacher so that thoroughly balanced and basically satisfying outcomes result. However, for an objective analysis of the basic mathematical concepts, understandings, and processes of a mathematical experience, a comprehensive and valid testing instrument can be efficient and valuable.

Such an instrument, to have validity, must conform to the course material taught. For this reason, no test can be given for this type of a unit which will be valid every time the unit is used. The individual interests of the student personnel will stress different phases at each teaching period, thus making it necessary to adapt the evaluation medium to the particular subject matter fields which have been emphasized, and at the same time, it must assure adequate evaluation of the understandings of the basic concepts of mathematics.

In any such instrument the problem is to evaluate, as nearly as possible, each branch of the industrial applications considered, and also, to check student understanding and uses of formulas, equations, tables, graphs, scale drawings, and geometric forms and constructions as they present themselves in practical situations. Besides the evaluation of the student's ability to recognize the applications of his mathematics in his daily contacts, it is necessary to ascertain his ability to deal with them with facility and skill. This phase may be handled by a test or tests dealing with basic functions and keyed to the "Check List." Such tests used at strategic intervals throughout the course of the unit guide both teacher and student toward a satisfying and profitable culmination of an outstanding mathematical experience.

Thus, with an adequate evaluation program accompanying a carefully planned and executed course of study, the recommendation of the Post-War Planning Commission for a two-year general or applied mathematics course, augmented by the "Special Interest and Computational Workshop," should prove an invaluable asset in activating, enriching, and democratizing the mathematics curriculum of the secondary schools.

Advertising men are in one of the highest-paid occupational groups. More than 29 per cent of all advertising workers make salaries of $10,000 a year and over.

TEACHING SCIENTIFIC METHOD IN THE JUNIOR HIGH SCHOOL*

H. G. McMULLEN

Deerfield-Shields Township High School, Highland Park, Illinois

This audience is well informed on the methods used by scientists in solving problems. You are equally well informed on the attitudes one must possess if he is to use these methods successfully in arriving at verifiable generalizations.

I doubt that any science teacher would omit from his list of objectives those that deal with the teaching of scientific methods and attitudes. Neither would he neglect teaching these methods, nor attempting to develop these attitudes in his science teaching.

Why, then, do we continue to talk and write about the scientific method? I believe that one of the reasons for our continued interest in this subject is that we are not satisfied with the results we have achieved with our pupils in arriving at understanding in this area of thinking. Perhaps these unsatisfactory results are partly due to the fact that, as science teachers, we have emphasized the efficacy of this method in solving science problems, but have not generally extended it to the solution of problems outside of the area of science.

There is a growing belief that man may be relieved from many anxieties by a wider application of the methods of science to problems that up to now have not been subjected to the rigors of scientific methodology. An increasing number of social scientists and sociologists suggests that we use scientific methods to solve all our problems. As science teachers, many of us are becoming increasingly interested in this possibility. There seems to be a growing tendency on the part of science teachers to move away from the teaching of only science and to give more consideration to the application of science methods to solve our social predicaments.

At the Junior High School level we need not be too much concerned with teaching the technical methods of the scientist. The use of precision instruments to make extremely accurate measurements, the analytical and mathematical treatment of such quantitative data as may be obtained through these precise and objective techniques are perhaps beyond the scope of Junior High School Science. Rather, I should think, the science teacher might be concerned with science as a general method for solving all kinds of problems, and in his teaching at this level, be most concerned with teaching those general concepts which could be applied to a wider set of problems outside the field of science.

* Read at the Junior High School Group meeting of the Central Association of Science and Mathematics Teachers, Saturday, November 29, 1947.

We are not primarily training future scientists in our Junior High Schools; we are trying to educate future citizens. It is only in so far as the methods and attitudes developed in the teaching of science can be applied to the solution of problems outside the area of science that we will be successful in our goal of developing citizens who can and will think critically.

Not many of the problems that people are called upon to solve daily are, in their strictest sense, science problems. Most of our problems could be classified more properly, as personal and social problems. Some of us are willing to say that, even in science, it is only the science that has been proved to have social implications that will most likely be of value in the future life of the pupil.

The purpose of this paper is to discuss the possibilities of enlarging our concept of the scientific method, thus helping our pupils to apply the method to all types of problems. The teacher may then be of even greater help in the process of aiding them in making the necessary changes in their thinking and in their ways of adapting themselves to this ever changing world. To do this adequately we may need to adopt a somewhat broadened definition of scientific method.

Such a definition is found in Wendell Johnson's book, *People in Quandaries*.[1] According to Johnson, scientific method consists of, "(a) asking clear, answerable questions in order to direct one's (b) observations, which are made in a calm and unprejudiced manner, and which are then (c) reported as accurately as possible and in such a way as to answer the questions that were asked to begin with, after which, (d) any pertinent beliefs or assumptions that were held before the observations were made are revised in the light of the observations made and answers obtained." This definition implies, I believe, a form of human behavior which experience proves to be extremely rare outside the realms of science inquiry, a method seldom used, even by scientists, in solving problems other than those of a strictly scientific nature.

I would like now to analyze this definition in relation to some of its significance in the teaching of Junior High School Science. For the purposes of this paper, I will ask you to accept Mr. Johnson's definition of the scientific method. The first step in this definition is the asking of questions. These questions must be stated clearly, and they must be answerable. That is, they must be capable of experimental investigation resulting in the accumulation of verifiable facts.

Pupils frequently fail to make a distinction between questions that are temporarily unanswerable because of the absence of necessary information, and those that must forever remain unanswered because

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[1] Johnson, Wendell, *People in Quandaries*. Harper and Brothers, 1946.

there is no way of ascertaining the facts necessary for an answer. For example, the question "How can we prevent cancer in human beings?" cannot be fully answered at the present time because we do not have sufficient information on the subject. The question may be answered when enough information has been accumulated, or when new techniques of investigation have been devised.

The question "When I die shall I go to heaven?" cannot be answered scientifically for it is quite impossible to obtain experimental information about such verbalizations as "heaven."

Some questions then cannot be answered by scientific method because there are no known ways of obtaining factual information about them. I believe that Junior High School pupils can be made to understand such distinctions and thus realize this limitation on the kinds of questions that can be answered by science.

Questions asked by pupils may be divided into those that ask *how* things behave and those that ask how things *should* behave. It is possible to make the pupils understand that science does not concern itself with how things *ought* to behave, or what one *should* believe. Personal prejudices cannot be tolerated in answering a question scientifically. It is possible, by the methods of science, to show several possible, alternate courses of action. The ways of achieving any of these courses may be determined and the results of pursuing these courses may be predicted, but science cannot determine which course of action *should* be pursued.

Opinions are not determined by the scientific method, although they may be tremendously influenced by the results of scientific exploration. Cultural preferences, religious creeds, political or economic standing may greatly influence the course of action finally followed by an individual. This need not affect the validity of science nor its applications. A drug such as streptomycin is equally effective, when properly prescribed, whether it is used in treating a Christian or a Mohammedan.

The lack of clearness in the formulation of pupil questions may arise from certain language difficulties that have been brought to light by the semanticists. We must help our pupils distinguish between words and the things which the words denote.

It is difficult for some children to comprehend that we have coined words for "things" that do not exist. We talk about "things" that do not exist and by talking about them long enough we may be able to convince ourselves, and others, that they do actually exist. We must challenge the words which are symbols for the actual things they denote. The thing denoted is the referent and one should be able to conjure up a picture of the actual thing denoted by the word, even sketch and diagram it, if it belongs to referential language.

Science properly deals with real things, and in formulating questions we must avoid using words that are on too high a level of abstraction. If a question cannot be reworded and expressed in words that have referents, existing in the real world, then probably the questions will not be capable of solution by science methods.

If we cannot see where an abstraction stands in relation to reality, we shall not be able to clarify the meaning of abstract words by showing their connection with concrete situations. We determine what is a concrete situation through the evidence obtained by means of our senses. Of course, in science we do use words for which we may not actually have a thing "existing." We theorize about such abstractions as the ether, electrons, and genes. We say that if such concepts are to be useful then certain things will happen when we perform certain operations. We try the experiment and if our predictions work out we say they have helped us to verify the concept we have hypothesized. We recognize such words as abstractions and willingly scrap them if we find that new discoveries require a different orientation and a new hypothesis.

As an example of a word which can be highly abstract, which must be interpreted in its context and by finding a referent for each usage, if we are to know its meaning, we may use the word "control." We use this word in a variety of ways in science, and in even more ways outside of science. We speak of the levers which *control* an airplane, of losing *control* of a car, both as a financial way of losing it through non-payment and in the physical sense of wrecking it. We talk of *controlling* an experiment. A *control* may be the catalyst in a chemical reaction, or the man who had the reaction under his *control*, thus *controlling* the *control*. Whenever such a word is used we must try to help the pupil find an archetype that will enable him to get his feet on the ground before we proceed to use the word in a question that we hope to answer.

I believe we can help our pupils to determine what kinds of problems can be solved. We all recognize that men are frequently and sometimes foolishly concerned with problems for which it is impossible to find solutions. Vague or meaningless questions will of necessity result in vague or meaningless answers. If a question cannot be worded so that it refers directly or indirectly to experience or observable actualities, then the question is not to be answered by the methods of science. If we cannot find the operations by which the question can be answered, then we cannot answer the question by scientific methods.

So long as our teaching remains strictly within the bounds of science we are not likely to have much difficulty in proposing meaningful problems. Most of us, however, feel that we should extend our science

teaching to the consideration of socially significant problems that develop because of science discoveries. It is here that we begin to face real difficulties in framing questions so that we may use the methods of science in arriving at solutions. If we cannot state a question so clearly and meaningfully that there is general agreement on the observations needed for obtaining the data and the specific conditions under which the observations are to be made, then we probably are asking a question that cannot be answered by means of science methods. Furthermore we will often find that when a question is stated precisely and clearly, the operations by which is is to be answered and the conditions under which they are to be made are implied in the question.

If we do not ask a question that indicates where and when one may reasonably expect to find an answer, then we shall need to restate the question until it is asked in these terms, if we hope to find an answer. If we challenge each question proposed by pupils by asking them to state exactly the methods by which they would collect reliable data to answer the question, we will, I believe, soon have them asking only clear answerable questions. They will learn the futility of trying to answer questions for which there are no answers.

Assuming then that we have asked an answerable question, the next step is the making of observations in a calm and unprejudiced manner. Before observations are made, it may be appropriate to propose some kind of hypothesis that will direct the observations into what appear to be fruitful channels. These proposals, of course, remain assumptions until they have been verified by facts. It is this guessing that gives direction to the observations that are to follow. The accuracy of the hypothesis is very often closely correlated with the successful past experiences in a similar field that has been explored by the person formulating the hypothesis. This fact may make it necessary for the teacher to aid the Junior High School pupils in formulating some of their guesses. As the observations are made, it may be necessary to revise the hypothesis or in some cases to discard it entirely if it proves to have been a particularly bad guess. It might be helpful for Junior High School pupils to trace historically how some hypotheses have been formulated, tested with the facts, evolved into theories, and when the available evidence has accumulated over a period of time and has not been contradicted, have finally been accepted as science facts.

We may organize classwork so that it will give pupils more opportunities for observing, classifying, measuring, experimenting, explaining, describing, and for evaluating authority, for all of these activities are involved in obtaining data.

As a step in obtaining data, we might give pupils more practice in

observing, and in describing accurately what has been observed. With slight encouragement pupils of this age will bring into the classroom an almost endless variety of articles. From these may be selected for further study and exploration those objects that seem to create the most interest, or those for which the teacher feels an interest should be created.

In making observations the pupils might be encouraged to look for qualities that this particular object possesses that makes it look like other things they already understand. Next they might look for the things that differentiate this object from all others. In describing these qualities the use of words should be carefully checked. The pupils should select critically those words that will most accurately describe the quality under observation.

This might be the place to discuss with the class how science demands that the terms used should be accurate in meaning. The language of science is precise and the terms used must be carefully defined according to their current usage. Very often a single term may be introduced that describes an object accurately, where previously many words were used to express the same concept. Thus both wordiness and ambiguity can be avoided. The language of science is meaningful in that it refers directly or indirectly to experience or observable actualities. Pupils who have come to understand the need for learning precise terminology may accept more readily the necessity of learning the very large and technical vocabulary that is required in science.

A study of the classifications made by scientists and the reasons for such classifications is not beyond the Junior High School level. Keys may be employed and students may be asked to prepare a key for the identification of some common group of objects.

In making some observations instruments are desirable. The limitations of the instrument may be discussed, and further, the instruments may be discussed from the standpoint of how and why they were made. It may be possible for pupils to construct some simple instruments that would render their observations more meaningful. Instruments used in measurement enable us to give greater refinement to the measurements we make. The degree of refinement achieved in measurement should be adapted to the problem, and for most of our work, need not be carried to extremes of exactitude.

Certain statistical techniques involve no more mathematics than Junior High School pupils understand. Errors made in using statistics might be discussed, such as the comparison of numbers which are not comparable. Whenever relative numbers are being compared the base must be properly chosen so that each set of numbers have a common basis. If we are using numbers derived from sampling a large universe

of data, we must be sure that the sample is an accurate cross section of that universe. If numbers are being compared which were compiled at different times, we must be sure that the same methods and same type of sampling are used at each time. The correlation coefficient is perhaps the most often misinterpreted of all statistical measures. We recognize that high correlations may occur due to pure chance, and we must be extremely cautious that we do not interpret such relationships as in any way related to cause and effect. Junior High pupils find many examples of the misuse of statistics in their reading, and with help from their mathematics and science teachers, they may be able to detect some of the more glaring misuses of numbers and thus when making interpretations of their own data employ statistics correctly.

Assuming now that we have asked a question and made the necessary observations, the next step in the method as we are defining it, would be to report the observations as accurately as possible, and in such a way as to answer the question originally asked. The way in which the data are organized and summarized helps to determine what conclusions can be drawn from them.

This particular area of thinking was studied by the Evaluation Staff of the Eight Year Study, and has been reported upon in full in their publications.[2] Our chairman, Dr. Hartung, played a prominent role in this study, and can tell you, much better than I, about this phase of the scientific method. However we will consider a few of the precautions that one must observe in interpreting data—some that Junior High School pupils might be expected to use. We might expect pupils to discover the factors that are causing the conditions in the data, if these causes can be determined from the data. We might also expect them to be able to predict some of the possible effects the conditions described in the data may have on future happenings. This ability to make accurate predictions from data is probably the most valuable outcome of scientific investigation.

Pupils, however, must be made aware of the ways in which predictions are qualified so as to take into account all limitations that exist because of the inadequacy of the data. We would expect pupils to recognize that data alone will not permit the making of value judgments. Words like ought, should, best, bad, et cetera which imply values, cannot be used in making scientific interpretations of data. The only acceptable judgments made about data are those that involve questions of the relevancy of data, the weight to be assigned to each aspect of the data, and the general interpretation that can be made from the observed events that resulted in the data. The costs

[2] Eugene R. Smith and Ralph W. Tyler and the Evaluation Staff, *Appraising and Recording Student Progress*, Harper and Brothers, 1942.

and consequences of alternate courses of action may be determined through an investigation of the data, but the preferences for a certain course of action cannot be determined by science methods.

If experiments are done in solving problems, certain precautions should be followed. In all experiments some factors are controlled, others are assumed to remain constant, therefore, not affecting the observable results of the experiment. These assumptions should be challenged, and in some cases checked, to be sure that constant factors are remaining constant and therefore can be disregarded in interpreting the results. In so far as possible only one variable should be permitted. If there are uncontrollable variations in the experimental set up, either techniques may be devised for compensating for them, or the interpretation of the results must be carefully qualified to take into account these factors. The danger of basing generalizations upon too few instances is often overlooked in using the experimental method. If it is possible it is well to have several pupils do the same experiment and pool their results. A distinction may be made between demonstrations and experiments. A successful experiment always obtains an answer to a question to which the answer was not previously known. It may be possible to develop an experiment from a demonstration by varying some factor that previously was controlled in the demonstration, and thus introduce a condition which will produce an unknown result. The part that the observer's emotions, senses, experience, et cetera play in the experiment may also be considered as a part of the interpretation of the results of the experiment.

It should be possible to work gradually from problems which demand little more than accurate observations and simple manipulations to those that require the use of apparatus and instruments which lead to measurement and simple calculations. In reading about experiments that have been performed by others, pupils should note and criticize the safeguards that were used in conducting the experiment. Some of the questions that might be asked could include the following: What factors were controlled? Was the sampling adequate? Has the work been verified by other competent investigators? Do the results obtained through the experiment enable one to make accurate predictions?

In studying the reports of others, pupils can be trained to assume a critical attitude. The evaluation of authorities then becomes a significant part of the method of science. Most of our knowledge of science must be acquired through reading. There are too many facts to be learned to achieve all of them by the time consuming methods of experimentation and direct observation. Because this is true we might spend more time in aiding pupils to learn how to evaluate au-

thorities properly. Science research workers never overlook the pertinent papers that have been published in their fields of research. The proper evaluation of the results reported in these papers becomes an important part of their method of working. They evaluate these reports in the light of their own experiences and accordingly reject or accept them. Our pupils frequently are hampered in this process by not having had enough experience to make sound judgments of the accuracy of the things reported. Because of this they may have to evaluate the authority rather than what is being reported. Some of the questions they might ask could include: How much training has this individual had in the field of knowledge about which he is reporting? Where was this training obtained? Has he been accepted as an authority by others? By whom? Does he have a particular bias? Is he reporting results that have been obtained in his field or is he attempting to transfer his authority to another field? Does authority transfer? Under what conditions? What authorities does he quote? What do others in his field say about his work? These and other questions about the authority may give our pupils sufficient information so that they can either accept or reject the material being read, when it is impossible for them to know whether the facts actually do agree with experience. We recognize that no authority is completely infallible, but also appreciate that we must accept some authority if progress is to be made. It is quite impossible to obtain all our knowledge by first hand observations.

The last step in the use of scientific method, as we have defined it, is the revision of any pertinent beliefs or assumptions which were held before the observations were made, if the results of the investigation indicate that such revisions are necessary. This step involves an attitude, or a way of behaving, that is perhaps found only in persons who are convinced of the efficacy of the methods of thinking that they are using. One must believe in the basic notion that everything is in a state of continuous change. This results in an adaptability or a readiness to change as knowledge is gradually accumulated. One of the objectives of education that we, as science teachers, may be able to accomplish, providing we are willing to give sufficient effort and time to it, is to develop a faith in science as a method of observing. recording, generalizing and interpreting human experience. The method as applied to science problems does have universal acceptance Its values are undeniable. Are we willing to accept a share of the responsibility for extending these methods to all problems?

The popular attitude toward science seems to be that it is a creator of gadgets, drugs and machines which may be used to man's advantage, but there is little evidence that the general public is adequately informed about the rational methods of science which make is useful

in solving all kinds of problems. As teachers we can help to keep our pupils informed of the authoritative advances being made in science and the manner in which the scientist achieves them. Through an understanding of the method, the non-scientist may become more effective in making his own discriminating evaluations between that which is based upon fact and that which is being reported prematurely or without adequate basis.

A faith in the methods of science will not result in disillusionment, for it is the only method so far developed by man by which reliable knowledge is consistently being added to our growing understanding of the world.

The advantages of these methods are concisely stated in Cohen and Nagel's book, *Logic and Scientific Method*,[3] in these words: "Scientific method is the only effective way of strengthening the love of truth. It develops the intellectual courage to face difficulties and to overcome illusions that are pleasant temporarily but destructive ultimately. It settles differences without any external force by appealing to our common rational nature. The way of science, even if it is up a steep mountain, is open to all. Hence, while sectarian and partisan faiths are based on personal choice or temperament and divide men, scientific procedure unites man in something nobly devoid of all pettiness. Because it requires detachment, disinterestedness, it is the finest flower and test of a liberal civilization."

[3] Morris R. Cohen and Ernest Nagel, *An Introduction to Logic and Scientific Method*, Harcourt, Brace and Company, New York, 1934.

THE QUIZ SECTION

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1. A man, putting a screw into wood, *pushes* on the screw-driver as he *turns*. How do you compute the work done?
2. A vertical U-tube is partially filled with water. If, now, the levels are displaced (by momentarily applying air pressure at one end, say), find the period of oscillation.
3. If the tube in No. 2 were filled with mercury would the period be different?
4. A train traveling *south* exerts a slight sidewise force on the *western* rail of the track. What do you think of this?
5. The horizontal range of a big gun is equal in length of the latus rectum of the parabolic path. What is the angle of projection?
6. A particle at the top of a smooth sphere rolls off. Where does it leave the sphere?
7. Where does the p article in No. 6 strike the horizontal plane on which the sphere stands?
8. If the sphere in No. 6 were rough would the particle leave the sphere sooner or later?

COMPARING WEIGHTS OF MOIST AND DRY AIR

BEN STASCH

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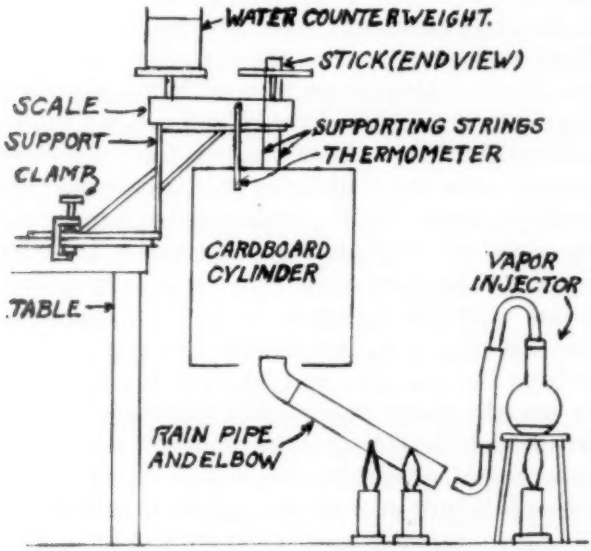
"It was as though someone had pumped the air out of space and filled it with a vapor of humidity which lay heavy as lead." *East River* by Sholem Asch.

". . . the heavy summer air of Florida" *Cross Creek* by Marjorie Rawlings.

". . . and the air becomes heavier and heavier with moisture." *Cradle of the Deep* by Joan Lowell.

"Of course," says John." "If you add something to something else it stands to reason that the mixture has to become heavier. On a moist day like this you can feel it."



"What does the barometer read now?" you ask.

"28" says John. "It just doesn't hitch. During fair weather last week it was 29."

"Blow in on the exhaust tube of the barometer," you say. John blows and the mercury goes up.

"Now take some air out, John" you say. John does so and the mercury goes down.

"If today's moist air is heavier what would the mercury do?" you ask.

"It would go up" answers John perplexed.

"Since the air today is humid and the mercury has gone down it proves that moist air compares how in weight with dry air?" you ask the class.

"It is lighter" the class answers dutifully.

Calm and serene in your faith that logic and the experimental method have again triumphed, you give them the monthly test and find to your dismay that a quarter of your pupils still say that moist air is the heavier. You find that humans project their feelings into a substance or situation and ascribe to it qualities which it does not possess. This personification is often so strong that you must perform more than one experiment to break it down. So you must weigh equal volumes of moist and dry air.

With very light poster cardboard and glued tape make a cylinder 18″ to 20″ in diameter and 26″ to 28″ high, closed at the upper end and with a hole 6″ in the lower end. Do not make the cylinder of metal. Its inertia is too great and the metal conducts the heat out so fast that the vapor condenses inside. By means of two strings, hang it from a light stick placed across the center of the scale pan. Tie a thermometer to the scale support arm so that it goes down through a small hole in the upper end of the cylinder. Level the scale with a water counterweight. When the rain pipe is heated, hot air free from water vapor will enter the cylinder so that it becomes lighter. When the thermometer reads 160°F. (which will approximately be the temperature of the air and water vapor mixture in the cylinder) level the scale again and hold the scale pans level so that the uprush of vapor will not push the cylinders up. Inject vapor from the flask through the rain pipe into the cylinder 4 to 6 seconds, remove the steam tube from the rain pipe and let go of the pan. According to Avogadro's law the water vapor will drive some of the air out of the cylinder through the hole in the bottom so that there will be just as many molecules of air as there were before the vapor was injected. As water vapor is lighter than air the mixture is lighter than air.

It is well to introduce this experiment with a demonstration showing that water vapor will drive some air out of a free space. If you put a burning splint into a large flask, it will keep burning, but if you boil a little water in the flask, the flame goes out at once.

If you test pupils after these experiments their faith in what they have read and heard is still so strong that five to ten percent will insist that moist air is the heavier. Indoctrination is sometimes more influential than the experimental method.

The history of the world is the biography of great men.

FROM A TATTERED OLD NOTEBOOK

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As textbooks get fatter and fatter, physics teachers are kept in a quandry, trying to decide which topics are the most fundamental. As our classrooms become more and more crowded the added clerical work keeps a teacher, who is already over-burdened with details, from doing the things he would like to do in presenting his subject. With the increase in the number of pupils the teacher is naturally confronted with a more limited capacity to learn. Average classrooms have only a few students of the mental heavyweight type and a considerable number of only humble intelligence.

In the hope that these suggestions may prove useful to other teachers faced with these problems, I am offering here a few associations or teaching aids that have helped pupils retain certain concepts.

Visible Spectrum. In studying the visible spectrum, the order of the colors may be remembered by recalling the name ROY G. BIV, the letters in the name standing for Red, Orange, Yellow, Green, Blue, Indigo, and Violet. If the class is not too sophisticated, one might mention that ROY is the boy looking for the pot of gold at the end of the rainbow. Sort of a fairy tale, yes, but consider Newton and the apple, Archimedes and the bathing episode.

Levers. In studying levers, the following has been useful as an aid in remembering the three classes. Where FULCRUM, RESISTANCE (opposing force), and EFFORT (applied force) are involved,—use the word FRE, a simplified spelling of the word "free." F is the *first* letter of the word, and the FULCRUM is the part of the lever placed between RESISTANCE and EFFORT in the *first*-class lever; R is the *second* letter of the word, RESISTANCE is between the EFFORT and the FULCRUM in the *second*-class lever. E is the third letter of the word, and EFFORT is between RESISTANCE and FULCRUM in the *third*-class lever. (See Fig. 1)

Boyle's Law. This law may be illustrated by means of a sponge. Let the sponge represent the volume of the gas and one's fist the pressure. As one squeezes harder and harder, the sponge (volume) gets smaller and smaller. Also I have found that students remember Boyle's law is concerned with pressure by pointing out that anyone afflicted with "boils" is well aware of pressure.

Open and Closed Pipes. In dealing with open and closed pipes where the length of the pipe is related to the wave length of the note produced, pupils often have difficulty remembering that in the open pipe the length is one-half the wave length while it is one-fourth the wave

length in the closed pipe. The word "Foreclosed" may be used to associate one-*fourth* with the closed pipe.

Dyne and Erg. These terms seem to have more meaning and are better understood when attention is called to such words as DYNamite, DYNamo, DYNamic, hetroDYNE, and enERGy.

Pi. That pi (π) refers to a circle can hardly be forgotten when one thinks of a pie which in most cases is round.

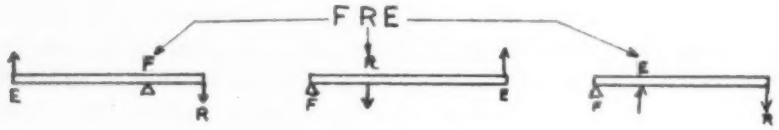

FIG. 1. Classes of levers.

Ohm's Law and Power. In both of these cases the letters in the circles are in such relative positions that the mathematical processes of multiplication and division are indicated and easily recognized.

$$E = RI \qquad R = \frac{E}{I} \qquad I = \frac{E}{R}$$

$$W = EI \qquad I = \frac{W}{E} \qquad E = \frac{W}{I}$$

Jet Propulsion. On one of the newer pages in the old notebook is found the very simple idea of a rubber balloon inflated and released. Its manner of zipping through the air, based on Newton's Third Law, is the basic principle of jet propulsion.

No doubt there are many other helpful ideas and methods that a busy teacher would be glad to use. Let's get them into circulation.

Education makes people easy to lead, but difficult to drive; easy to govern, but impossible to enslave.

—LORD BROUGHAM

Within yourselves deliverance must be sought:
Each man his prison makes.

—*Edwin Arnold.*

PLANT SCIENCE AND HUMAN LIVING*

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It is possible to imagine human life on this globe without any animals; but we cannot conceive of a world like ours without plants. Because of their important role in the whole chemical cycle, plants are at once recognized as indispensable. They also serve a greater variety of purposes and uses too than do animals.

Neither does there seem to be any good reason why a course in general botany is not at least as basic and cultural, both biologically and philosophically considered, as one in zoology. Nevertheless, botany for the general student is often looked upon as a kind of ornamental or lady-like science in which the student may learn better to appreciate "flowers" and "trees." For others, it is made a requirement for subsequent courses in agriculture, forestry, pharmacology, and the like. Only the barest fundamentals which are directly appli cable to the particular speciality are considered in these cases.

Unhappily among many of the teachers of the natural sciences there is not a vital overall concept of the complete chemical cycle wherein the green plant plays a most important role. The green plant is really a pivot upon which the continuity of the inorganic and the organic world revolves. This fact is often but slightly if at all seriously considered. Still much more unusual is the appreciation of the entire hierarchy of *beings* in the universe. Botany is therefore often designed to serve as a polite pedagogical potion to be injected as painlessly as possible. Thus it satisfies an arbitrary, if not a more or less meaningless requirement. Like many of the subjects in a modern educational curriculum, botany is too often isolated and serves no integrating or cultural purpose. It may therefore be compared to a casual green patch in a crazy quilt!

To continue a logical gradation, that is, from the inorganic and organic beings to animate beings, including both plants and animals, man's own true place in nature cannot be ignored. After due consideration of the subject to be taught—its place in relation to the rest of the universe—certainly, no less important is a consideration of the learner himself. Man is the most complex creature in the world. This is precisely because he is a rational animal, that is one endowed with intellectual and spiritual attributes. These rational characters should dominate all of his animal powers and propensities. We can do no better here than to quote the great Pascal who said:

* Read before The Botanical Society of America at the Stevens Hotel, Chicago, December 28, 1947

"It is dangerous to show man in how many respects he resembles inferior animals, without pointing out to him his grandeur. It is also dangerous to direct his attention to his grandeur without keeping him aware of his degradation. It is still more dangerous to leave him ignorant of both."

Modern education seems to have left us in a dilemma. Two world wars, both unspeakably horrible, and our recent record of juvenile delinquency, not to mention the rampant criminality and degradation of adults, all bear painful testimony to our steady and increasing moral decline. That we, as Americans, have lost the middle of the road, there seems to be no necessity for argument and no room for defense. As teachers, all of us must influence youth particularly. No subject therefore is too technical, too routine, or too automatic to permit us to overlook the fact that both the teacher and the learner are human beings and must function as such.

In this age of modernism there is a kind of worship of the human mind dominated by greed and selfishness. This attitude is most inconsistent in many who claim at least to believe that intelligence in man differs from that of the inferior animal only in *degree*, and not in *kind*. This particular attitude might more logically follow from a consideration of the mounds of wreckage and ruin which humans are heaping up the world over.

It is encouraging to find that many teachers are now more greatly concerned with the degree of discrimination, the power to analyze and to evaluate, which the young mind acquires, than the amount of factual knowledge which they might stuff into it. The teacher's greatest concern is with the effect of school and college experiences on the right development of the most precious things on earth—human lives and living.

In the very near future, it seems, our present world civilization will either be annihilated or rehabilitated. The teacher is in a key position to get down and to go in bare-handed to do the lion's share in cleaning up the rubble which modern ways of life and living have heaped up. What we mean is, that with our rapid passing through an epoch of scientific, materialistic so-called progress, with moral and spiritual values definitely ignored, this boom of progress is now somewhat depressed. In this all are forced to agree and must realize that we are now living in the most humiliating period in the history of the world.

Humility, it seems, is the final lesson for some of us humans. At that it takes the blast of an atomic bomb to drive it home. If it is not already too late to re-establish the moral and spiritual values in human lives and living, it will be possible to direct our budding geniuses toward the business of saving and restoring what they would otherwise be prone to plunder, to exploit, and to destroy.

Charles Seymour, president of Yale, has said: "There is no field in which the vigorous and combined leadership of educational institutions at all levels is so needed as in the spiritual."

The true history of America from her infancy, sad to admit, is one of pillage, waste and devastation—one which must bring the blush of shame to every well-balanced citizen. For, as a nation, with our manifest destiny policy, we have almost completely exterminated the Aborigine, while robbing him of his home; we have brought the Negro from the depths of Africa for a life of cruel bondage and persecution, in satisfaction of our own lust and greed; we have exploited immigrants from the far East, keeping them in semi-bondage, segregation and undercompensation; we have acquired territory beyond our bounds regardless of our motives or means. In our ruthless exploitation of the natural gifts and fruits of this great continent, we have laid low her mighty forests of majestic trees; we have polluted her limpid streams, pulsating with life and balanced growth; and, particularly where human labor was cheap or still in bondage, we have rudely pressed the tender, free-flowing bosom of Mother Earth herself, far beyond her natural powers to yield; or left her naked to the merciless sport of wind and weather.

These are some of the disgraceful truths which we, as teachers, must expose to our students and must emphsaize in every course especially in natural science. We must also point out the great good which men of science have done—all perhaps which lies within human power to do—in their noble effort to restore and to compensate for the serious waste and exploitation of our natural resources. But this restoration and renovation of material goods is not enough; for man does not live by bread alone. In his present crucial position, it is necessary to appeal to man's essential qualities, his human faculties, to his nobility, if you will; in a word, to his God-given powers and privileges which unfortunately some have ignored.

* * *

Just as there is a hierarchy of *being* in this universe—a hierarchy which extends from the inorganic through the organic, the animate and the spiritual orders—there is also a hierarchy of knowledge, that is, *science*. Therefore, science, in the ascending order, includes the *physical* or *natural sciences*, *mathematics*, *metaphysics*, and *theology*.

This grading of the sciences is analogous to the hierarchy of *being*. We cannot reduce all the sciences to one and the same level. If, on the other hand, we conceive of them as analogous, we make allowance for their differences without destroying their unity. This makes for democracy in the world of science where the functions and offices are

at different levels. Here Jacques Maritain (*Science, Philosophy and Religion*, page, 179) remarks:

"An army in which anybody may be general is not the army of democracy, but of stupidity. A republic of knowledge in which each type of knowledge claimed for itself the architectonic rank, or where it was declared that no one body of knowledge had a higher rank than any other, or a superordinate regulative role, would be a republic of ignorance."

Many Americans do not realize the relation between the dignity of the individual human being and democracy. They seem not to know that the Declaration of Independence makes of American democracy a philosophy on the nature of man. No previous government took the brave step of declaring the moral truth that every man has rights, a personal dignity and a personal value. So much attention has been given to the political aspects of our government that many are unaware of the spiritual aspects of true American democracy. This basic principle which upholds the dignity of the individual is epitomized in the second paragraph of the Declaration. We may well pause here to ask: What has happened to this principle and, consequently, to this democracy?

Each one of us in the field of education is first, a teacher, and secondly, a teacher of botany. The mere amassing of facts of plant science or of any other science will never educate or make a man wise. Knowledge is not wisdom; and too often much of it cannot be regarded as more than a confusion of facts. It requires wisdom to supply order. It is necessary to go back to first principles in order to see the relation of one truth to another, one science to another, and, what is most important, the relation of all truths, all sciences to the last truth, the final goal. The poet sums up this important distinction very beautifully:

Knowledge and wisdom, far from being one,
Have ofttimes no connection. Knowledge dwells
In heads replete with thoughts of other men,
Wisdom in minds attentive to their own.
Knowledge, a rude unprofitable mass,
The mere materials with which wisdom builds,
Till smoothed and squared and fitted to its place,
Does but encumber whom it seems to enrich.
Knowledge is proud that he has learned so much;
Wisdom is humble that he knows no more.
—William Cowper

The facts and findings of the natural sciences are indifferent in themselves so far as metaphysics and theology are concerned; but the interpretation of them and the uses to which they are applied may differ as true from false, as right from wrong as, for example, the difference between culturing bacteria for industrial uses and the growing of deadly germs for purposes of a most insidious and treacherous

method of human warfare. Only the correct application of first principles here can be the true safeguard against serious error. This is because man, being man, must face basic principles in the interpretation and application of scientific facts. One truth does not contradict another. It is necessary however that we have the truths—each at its proper level of knowledge—in order to appreciate their essential unity.

Man, the only creature on this earth who is capable of learning a science, is indeed a very complex being. This is so because of his twofold nature, the one which he shares with the lower animals, the other which includes his spiritual and intellectual endowments. As a rational animal, man must appreciate his true position in the universe as well as that of the object of his study. His rights over the world of material beings are his God-given privileges. These have their corresponding duties and responsibilities.

Man himself can neither create nor destroy, in the absolute sense. He is therefore obliged to respect the fruits of the earth over which, by Divine right, he holds dominion; and to learn to use these wisely and justly and with regard for his neighbor and with care for posterity. This is to say, man must render an account of his stewardship.

Conservation is necessarily a basic principle which any worthy course in natural science should stress. This cannot be really effective unless the ethical and moral implications go hand in hand with the otherwise barren physical facts. Precisely because of man's nature, he cannot function fully as a human being without a realization of his own true dignity and of his personal responsibility to his Creator.

In our age, largely because of the great advancement of natural science itself, man has forgotten the fundamental issues. One of the ills which is particularly symptomatic in the whole complex of our present human disorder has been diagnosed therefore as *megalomania*. In his quest and greed for material possessions, modern man has lost his balance and is blinded by the glare of certain accomplishments in the material order which are by no means owing to his own unaided powers.

The potency of an acorn under suitable conditions of environment and a long time period naturally insures the development of a mighty oak tree. This may be likened to the intellectual progress in the discovery and release of atomic energy as the culmination of many decades of patient investigation and experiment. In this, many great minds, each in his turn, unfolded an essential chapter in the final achievement. Unfortunately with the steady growth and progress in both the natural and intellectual orders, there has been a marked retrogression in the spiritual status of the generality of mankind. Nevertheless, the natural, the intellectual, and the spiritual poten-

tialities of man must develop and progress proportionately and harmoniously if he is to survive and to achieve his true destiny. Today the marvelous advance in the field of nuclear physics forces this consideration upon us.

In teaching plant science, as in every other subject in the curriculum, there is ample opportunity and dire need for the fostering of good citizenship based upon justice. In spite of all her present shortcomings and past misdemeanors, our Beloved America is still "the shrine of each patriot's devotion" and the one to which, now more than ever, the suffering world offers homage and looks for solace and succor in this hour of great distress. Among the loyal citizens of America are children of every race and color and clime. As teachers, therefore, we are obliged to the promotion of the Brotherhood of all mankind. And if our democracy is to signify anything more than a name, we must earnestly and courageously uphold the second great commandment:

Thou shalt love thy neighbor as thyself.

OKLAHOMA A & M COLLEGE RECEIVES NEW DIESEL ENGINE RESEARCH LABORATORY

A fully-equipped German Diesel engine research laboratory, valued at more than one million dollars, will shortly be transplanted to the campus of Oklahoma Agricultural and Mechanical College in Stillwater, Okla., it was announced today by John W. Studebaker, Commissioner of Education, Federal Security Agency.

Location of the former Klockner-Humboldt-Deutz laboratory at Stillwater will provide that institution with one of the two largest Diesel engine research centers in the United States. With allocation of the laboratory, President Harry G. Bennett of Oklahoma A and M announced establishment of the Oklahoma Institute of Technology, replacing the Division of Engineering of the College. Currently, Pennsylvania State College maintains the country's largest Diesel engine research center.

The KHD laboratory, formerly located at Oberursel, Germany, was assigned to this country by the Joint Chiefs of Staff shortly after VE-Day. Donation to Oklahoma A and M was made possible under a joint allocation of the Office of Technical Services, Department of Commerce, and the Office of Education, Federal Security Agency. In making a selection from 114 colleges, the Office of Education was represented by Dr. Ernest V. Hollis, Division of Higher Education. Serving as advisor on the allocation were members of the Automotive Industry Advisory Committee of the Department of Commerce and technical personnel in the National Defense Establishment.

Among major considerations involved in selecting the institution to receive the donation were the following:

(1) The belief that the national interest would be served by having a large Diesel research center located in the interior of the country away from industrial and urban centers.

(2) The desirability of having such a center located near the oil industry.

(3) The availability of college building space to house the laboratory. (Now engaged in a $15,000,000 building program, Oklahoma A and M College has designed a building to accommodate the laboratory.)

(4) The availability of funds to defray the annual expense of conducting Diesel engine research estimated to be $100,000 or more.

NOTES FROM A MATHEMATICS CLASSROOM

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152. Radians. If a trigonometry class has a few alert pupils, some one may ask "What good are radians? Feet and miles may sometimes be more convenient units than inches or yards. Are radians just a convenience or is there something special about them?" The textbooks explain fully how to convert degrees to radians, and vice versa, but do not answer the above question except to say that in problems that involve the methods of calculus it is convenient to use radians, and that in advanced mathematics the radian is used almost exclusively. I offer two explanations, and hope that future textbooks of trigonometry and pedagogy will fill this gap.

Consider the formula for the area of a triangle in terms of its sides. The formula is rather simple and is easily remembered because it uses half of the perimeter instead of the entire perimeter, as we can see by writing the formula without using the letter s. Evidently s is a convenient symbol just like the letter π.

Likewise, the formula for the length of an arc $L = r\theta$, using radians, is simpler in appearance than the formula $L = \pi r\theta/180$ which uses degrees. And the formula for the area of a sector, $A = \frac{1}{2}r^2\theta$ using radians, is simpler than the formula $A = \pi r^2\theta/360$ which uses degrees.

However, in a numerical problem, the apparently simpler formulas are of no advantage unless I have at hand a conversion table for changing degrees to radians. Without such tables I must still divide θ by 180 or 360, and multiply by π. And if the fraction $\pi/180$ or $180/\pi$ occurs in many other problems then it is convenient not only to have the conversion *table* but also a *name* for this particular combination of numbers. Hence we might say that radian is a convenient *name* for a certain number. Further, the fraction has a geometric interpretation just as the letter s in the formula for the area

The second explanation is for more advanced pupils. In calculus we need to find the limit of many algebraic and trigonometric quantities. (The class has studied limits in connection with geometric progressions the preceding semester.) One of the expressions on which a great many others are based is the limit of $\sin x/x$ as x approaches zero. The limit is the simple number 1. The class can easily test this fact by consulting the table which shows, in adjoining columns, the natural value of $\sin x$ and the value of x in radians. In the derivation of this limit, radians are used. Other formulas whose proofs depend on this fundamental limit, will then necessarily involve radians.

153. Mils. Ten years ago this unit was never mentioned in any high school text, so far as I know. But it may well be discussed in plane

geometry, as well as in trigonometry, in connection with finding the length of an arc. A mere statement of the definition, 1600 mils equal 90°, gives no clew as to why the number 1600 was chosen. Since a mil is approximately one thousandth of a radian, we have an explanation for its *name*. All discussions of the mil mention that for small angles a mil is approximately equal to the angle which is subtended by one yard at a distance of 1000 yd. The error is 2%, or less, for angles less than 340 mils. Thus from a few problems the pupil can readily see the advantage of using mils.

Our educational journals have failed to tell us anything about the history of mils, and I suggest that somebody fill that hiatus. When was the mil introduced? Where? What was the original definition?

154. Reviewing the Principles of Algebra. In a previous NOTE (Oct., 1943) I suggested a short daily oral review in geometry classes; and in another NOTE (Feb., 1944) I explained how the same technique could be used in an algebra class to review the operations. In this note I argue for similar short frequent reviews of the principles of algebra during the last two or three months of the beginning course.

In a geometry class a pupil is accustomed to talking about theorems, axioms, postulates, and general statements. If I say to a geometry class, "You know quite a few theorems of geometry. Who will state for us a theorem of algebra?" I usually get the answer, "There ain't no such thing in algebra." Hence I must explain that I refer to general statements about numbers like the general statements about points and lines; that you did not call them theorems, and very likely did not prove the statements. With some coaxing I can get a pupil to quote such general statements as "In an equation we may add the same number to both members" or "In an equation we may multiply both members by some number." But after mentioning the four operations applicable to equations, the class seems to think "There aint any more in algebra."

I mention all this merely to emphasize that in algebra classes we do not make the pupil sufficiently conscious of the general principles. At the start of algebra we use symbols like A_5, D_3, and M_6 to indicate what operation is used, but later in the work we may not always ask the pupil to state the general principle that he is using, and so the pupil forgets them. We slight the *vocalizing* of the general principle. The pupils become what I call *Number Pushers*. They push a number from one member to another; they push a factor out of the numerator and denominator. To change $1+(b/c)$ to a fraction, they push aside the number 1, writing c in its place; they push aside an exponent or a minus sign. I am inclined to ask the class, "Do you like to be pushed around for no good reason?"

To correct such troubles, I find it useful to have short (three to five minute) oral reviews at frequent intervals (alternate days) at the beginning of the recitation. There is time for five to ten questions like the following:

What is the fundamental principle of fractions?

In what kind of problem is it convenient to divide the numerator and denominator of a fraction by the same quantity?

In what kind of problem is it convenient to multiply the numerator and denominator of a fraction by the same quantity? (Ans. When simplifying a complex fraction.)

When it is absolutely necessary to multiply numerator and denominator of a fraction by the same quantity? (Ans. When we wish to change from one denominator to another?)

What is the difference of the squares of two numbers equal to?

What rule applies to the square root of a product?

What rule applies to the square root of a fraction?

What rule should you recall if I ask, "What does a times b times c equal?"

(Ans. We may take a times b or a times c but not a times both b and c.)

What many terms are there in the square of a binomial?

How do you recognize a quadratic equation?

What principle of arithmetic is used in solving quadratic equations by the factoring method?

What is meant by commutative operations?

What must be true about a common denominator?

In what kind of problems dealing with fractions do we not need a common denominator?

And if the reader is giving a course in Methods of Teaching Mathematics, let him assign for to-morrow's homework: Prepare a list of fifty similar questions that can be used in the last half of a course in ninth grade algebra.

155. Short Reviews in the Trigonometry Class. In no other high school course in mathematics are there so many formulas and relations between variables as in trigonometry. Some teachers feel crushed by the abundance of material and have tried to solve the difficulty of covering so much material by limiting the work to the solution of triangles. They justify this attitude by saying that we spend too much time on identities, that trigonometric equations are impractical except for astronomers, that the law of tangents can be dodged by drawing an altitude, that inverse ratios are only for professionals, and the half angle formulas are useful chiefly to prospective navigators.

I do not agree with this point of view. In all other courses I feel

crushed by the abundance of material, and must plan to use every minute carefully. (This is particularly true in courses in solid geometry.) But in the trigonometry class I never feel rushed; the course proceeds leisurely since a high school has about twice as much class time as many colleges give to the course. There is time to review theorems of plane geometry and many parts of intermediate algebra, and to fuse some of the disconnected topics from previous courses. The many formulas and relations need not be a burden if the class has frequent short reviews.

Beginning about the middle of the course I use short written reviews every second or third day. When the pupils are ready with paper and pencil, and I have a watch in front of me, I ask at intervals of thirty seconds questions like:

Write the reduction formula for $\cos(270-\theta)$.

What is the value of $\sin 150°$?

Write the law of cosines using the angle B.

What does θ equal if $\tan\theta = 1$?

Write any formula for $\cos 2\theta$.

What is the value of $\cos 330°$.

Sin $(-\theta)$ equals what function of θ?

Write the law of sines using the sides a and b.

Sin $(A+B) = ?$

In what quadrant is the sine negative and the cosine positive?

The correct answers are then read. Using ten questions, the entire test takes about eight minutes. As new relations are derived, questions about older topics are dropped, furnishing a continuous review. The relations are thus kept alive, and the pupil is conscious of his progress.

SCHOOLROOM LIGHTING GUIDE ISSUED BY FEDERAL SECURITY AGENCY'S OFFICE OF EDUCATION

More light in the school classroom doesn't necessarily mean better sight for school children according to "Lighting Schoolrooms," a 17-page pamphlet released today by the Federal Security Agency's Office of Education. Although more light is required in many classrooms, the provision of good seeing conditions is as much a matter of reducing glare and of eliminating sharp contrasts as it is of increasing the intensity of lighting, the pamphlet reports.

Brightness differences can be reduced by shielding the lamps, seating pupils so that they will not face windows, repainting walls and ceiling with pastel tints, and using lighter colored furniture and chalk boards.

Intended as a nontechnical guide for architects, school planners, and educational administrators, "Lighting Schoolrooms" furnishes recommendations suitable for remodeling as well as for new school construction. In addition to the problem of "brightness balance" the pamphlet briefly considers the type and location of windows and methods of artificial illumination.

THE USE OF GENERAL SCIENCE TEXTBOOK ILLUSTRATIONS

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In the first part of this talk, I propose to consider the role of the textbook illustration in the teaching of general science. In the second part, I shall review a number of experimental studies dealing with this problem. In my concluding remarks, I shall suggest the type of research yet needed if textbook illustrations are to be utilized under optimum conditions.

Textbooks illustrations have been variously classified. One writer (9) classifies them under four general headings: human interest, environment, quantity and processes. Examples under each of these respective headings would be a photograph, map, chart and diagram. Another writer (6) classifies the illustrations in biology textbooks as representative, analytical, charts and tables, and maps and graphs. A photograph and diagram are examples of representative and analytical illustrations respectively. The commonest method of classifying illustrations is as follows: photograph, drawing, cartoon, map, chart, table, graph, diagram and decorative design. This last classification is most appropriate for our purposes. I shall limit myself to three of the illustrations frequently used in science textbooks: the photograph, drawing and diagram.

The photographs in science textbooks are essentially representations of real objects or events. They represent three types of concepts: a) Those that the reader has seen already in real, or concrete, form; b) those from which the reader has been separated by factors of time or space, or both; and c) those that the reader could not have perceived in reality under any circumstances, e.g., an astronomical event, recorded by lapse-time photography.

As substitutes for reality, photographs are potentially capable of imparting meaning to the verbal symbols in the textbook. They generally are not as useful for this purpose as real objects or events. A real skunk, to select an obvious example, is certainly a much better type of material than a photograph to employ in teaching the meaning of the term "skunk." In the absence of real materials (or models), however, the teacher ultimately must resort to the use of photographic materials in teaching the meaning of terms. Photographs employed in this manner are helpful in reducing "verbalism," a condition in which students manipulate verbal symbols that are meaningless to them.

Photographic materials are not replacements for words. This point must be emphasized, for many persons tacitly suggest that photo-

graphic materials are not only capable of replacing words, but, somehow, are superior to them. When these persons are questioned, they invariably admit that they did not intend to create an impression of this sort. There is every reason to believe them, but as an antidote to the impression that they do create, I should like to approach the topic of textbook photographs from another avenue.

The contents of the mind, in the words of Karl Pearson (7) "ultimately take their origin in sense impressions, and in our modes of perceiving sense impressions." This postulation means in part that the mental content which helps to govern our behavior is derived from our many experiences. It further means that the mental content of a person varies with the manner in which he thinks. Pearson—and I know that you would agree with him—contends that there is no substitute for the scientific method of thinking.

Since knowledge is ultimately derived from sense impressions, it would appear that man possessed knowledge prior to the invention of language. The knowledge possessed by man in this remote past must have consisted of gross impressions derived from his surrounding habitat. A two-day old infant in our society possesses knowledge in this same sense. I am not prepared to discuss how knowledge of this type is assimilated and utilized. I do believe, however, that knowledge of this gross nature cannot by itself account for many of the intellectual activities carried on by man.

The invention of language, or verbal symbols, increased the scope of man's knowledge in two ways. First, language serves as a vehicle for one person to communicate ideas derived from experience to another. This function of language is well known to everybody. Secondly, language allows man to engage in higher intellectual activities. Bertrand Russell (8) states: "The advantages of words for purposes of thought are so great that I should never end if I were to enumberate them. But a few of them deserve to be mentioned." Mr. Russell then mentions the following two advantages: 1) There is no difficulty in producing a word, whereas an image cannot always be brought into existence at will, and when it comes it often contains much irrelevant detail. 2) Much of our thinking is concerned with abstract matters which do not readily lend themselves to imagery, and are apt to be falsely conceived if we do insist upon finding images that may be supposed to represent them. The statement, "Dogs, cats, and rabbits are mammals," exemplifies the first advantage. The word "dog," for example, represents the many dogs that we have seen. To bring each of these specific dogs to mind every time that we employ the term "dog" would, indeed, clutter up our thinking. The statement, "Atoms are known to consist of at least three basic parts, electrons, protons and neutrons," exemplifies the

second advantage. The facts in this last statement cannot be pictured but we do utilize them in our thinking through assigning names to them.

Language played a significant role in the development of science. The great discoveries in the field of electricity, heat, light, sound and atomic energy could not have occurred if man had not resorted to the use of words and other "abstract" symbols. Nor is it possible for general science students to understand many of the important concepts in these areas without employing words.

It would be unfortunate if you inferred in the light of the preceding discussion that students could master concepts of a higher intellectual level without first having a rich and varied experiential background. This is not the case, and a statement by Albert Einstein should serve to clarify the issue. This great scientist, as you know, supports the theory that our three-dimensional universe is finite, yet unbounded. He has attempted on numerous occasions to communicate this theory to persons like us. On one such occasion he preceded his attempt with the following observation. (1) "A geometrical-physical theory as such is incapable of being directly pictured, being merely a system of concepts. But these concepts serve the purpose of bringing a multiplicity of real or imaginary sensory experiences into connection in the mind. To 'visualize' a theory, or bring it home to one's mind, therefore means to give a representation to that abundance of experience for which the theory supplies the schematic arrangement." Einstein minimizes neither the importance of sensory experiences nor theoretical abstract arrangements. To his way of thinking, both are necessarily bound together, when one attends to many types of intellectual activities.

The invention of the photograph followed that of the spoken and written verbal symbol. Its function in the teaching of science has been considered once but is now worth repeating. The photograph is potentially capable of communicating concepts *per se* and imparting meaning to verbal symbols. It is a useful, although hardly indispensable, material of learning. Finally, it is not a replacement for the verbal symbol, and I submit the statements by Russell and Einstein in support of this contention.

The preceding discussion may seem far removed from what a teacher would want to know about the role of the photograph in the teaching of general science. In fact, it is not. The textbook photograph is best utilized by those who recognize its uses, limitations and relationships to words. There are unfortunately no pat rules that can be submitted for utilizing specific photographs in the teaching of science.

The drawings in science textbooks are, of course, constructed by

artists. Their role in the teaching of science is essentially the same as that of the photograph, assuming that they are realistic in style. They are inserted in textbooks under the following conditions: a) The editors prefer them to photographs, b) an event happened when nobody was about with a camera, c) the editors desire a photograph of a concept, but cannot obtain one, and d) a photograph will not reproduce clearly.

Drawings might vary in style from realistic to conventionalized. Illustrators, thus, are faced with the continual problem of determining which style should be used. This problem is not crucial from an educational standpoint, although almost half of the experiments on textbook illustrations have dealt with it.

The *diagrams* in science textbooks communicate organizational, operational or functional relationships. They generally consist of three components: a) Representations of the objects entering into the central relationship; b) Verbal symbols, employed to name parts, direct attention and so forth; and c) Symbols other than verbal but performing many of the same functions, e.g. dash-lines to represent motion.

Partially on the basis of a number of diagrammatic reading studies that I have conducted, the following recommendations for utilizing diagrams are submitted:

1) Whenever possible, do not utilize the diagram as the starting place in the development of a concept. General science students are likely to have difficulty translating the distorted outlines of the central objects back into three-dimensional reality. Employ the diagram, rather, as a follow-up technique.

2) Teach students the concept lying behind the construction of cross-sections in general. Many students are unaware of how cross-sections are developed.

3) Teach students the meaning of conventionalized diagrammatic symbols, e.g., arrows, dash-lines. These symbols constitute a special language.

4) Do not expect the diagram *per se* to communicate the concept of motion. Sophisticated adults, for example, frequently read motion into a diagram showing the four phases of a gasoline engine and expect students to do likewise. Many students, however, do not have the experience necessary for interpolating the missing instances in a diagram of this nature.

Experimental Literature

The experimental literature dealing with the illustrations in science textbooks is meagre. Kambly (3) conducted one experiment to determine whether pupils do or do not study illustrations. He allowed

345 pupils thirty minutes to study five pages of a science textbook, which included illustrations. He next gave the students a series of test items which could be answered only by those studying the illustrations. He found that 57 per cent of the total number of responses were correct and that 19 per cent of the total responses possible were omitted. Kambly concluded that many of the omissions were probably the result of lack of observation of the illustrations.

The findings in this study do not negate the role of the textbook illustration. They indicate, rather, that many pupils have not been trained to observe them.

Kambly (3) also conducted a study to determine whether textbook illustrations that are properly utilized by pupils and teachers contribute to pupils' achievement. One hundred fifty-nine students were given a pretest, then divided into two groups. Textbooks, including illustrations, were given to one group. Mimeographed materials, identical with the textbook except for the rewriting due to the omission of pictures, were given to the remaining group. The same supplementary reading and study materials were assigned to all of the pupils. A unit based on the materials was then taught and completed in three weeks. At the completion of the unit, the pretest was given as an achievement test. In making the comparison between groups, the number of points gained or lost after studying the unit was used. A significance ratio of 1.97 was found in favor of the group using the textbooks. This ratio might have occurred by chance alone.

The writer presumes from the report of the study that verbal tests were administered to both groups. The results of the test thus seem reasonable, for students at the high-school level are capable of manipulating verbal symbols whether or not the symbols are meaningful However, it is possible to construct an experiment that would make it impossible for those using mimeographed materials to compete with those employing books containing pictures. For example, let us assume that a book contains an illustration of an aardvark. Let us further assume that this concept was not available in any other form. An experiment identical with Kambly's could then be conducted. A test could be constructed at the end of the unit requiring the students to match the symbol "aardvark" with a picture or model of it. It is difficult to see how those employing the book containing this picture would not have an advantage over the others.

Hall (2) conducted a study of high-school students' preferences for illustrative materials. Sixty illustrations, including diagrams, cartoons and photographs, were submitted to 345 pupils in one high-school.The students were then requested to state their preferences for the different types of illustrations. The total group of high-school students pre-

ferred the types of illustrations in the following order: a) cartoon, b) diagram, and c) photograph. The results of this experiment are difficult to apply in practice. Each of the illustrations used by Hall has a specific purpose and must be utilized in terms of the educational objectives.

The writer recently has conducted two investigations on the ability of children to read diagrammatic materials. In one (4) of the investigations, 358 pupils, grades 4–8, were asked to match eight especially prepared cross-sections with their places of origin. From the results of the study, it seems fair to conclude that most of the children are unable to read many of the cross-sections appearing in their reading materials.

In the second (5) investigation, 227 children, grades 4–8, were asked to trace the flow of materials through a process diagram of a flour mill. The results showed that most of the children were unable to perform the required operation.

The implications of these two studies are to be found in part in the recommendations previously submitted for utilizing the diagram.

Studies Yet Needed

Studies of the following nature are yet needed if textbook illustrations are to be utilized under optimum conditions:

1) Studies to determine which of many photographic materials should be inserted in science textbooks. The teacher and pupil ultimately decide which photographic materials will be utilized. However, the types of photographs appearing in the book definitely structure their decisions.

2) Studies to determine the types of illustrative styles preferred by children. This problem is not crucial, although a book with aesthetic appeal is more likely to attract student attention.

3) Studies on the ability of children to read diagrammatic materials. The speaker believes that studies of this type can be utilized in "simplifying" diagrams.

4) Studies to determine the amount of recall effected by various sizes of the same illustration. Many teachers reject textbooks because the illustrations are small, although clear. There is reason to believe that the rejection of textbooks on this basis is not sound.

5) Studies to determine the best methods of placing illustrative materials on the page.

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PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2072. *W. W. Shirley, Stillwater, Okla.; M. Kirk, Philadelphia; W. J. Cherry, Berwyn, Ill.; A. MacNeish, Chicago.*

2076. *C. W. Trigg, Los Angeles City College; S. E. Field, Ironwood, Mich.; Hugo Brandt, University of Maryland.*

2075. *Carl V. Fronabarger, Springfield, Mo.; W. J. Cherry, Berwyn, Ill.*

2071, 5. *Felix John, Ammendale, Md.*

2074. *V. C. Bailey, Evansville, Md.*

2073. *R. A. Norbert, Berwyn, Ill.*

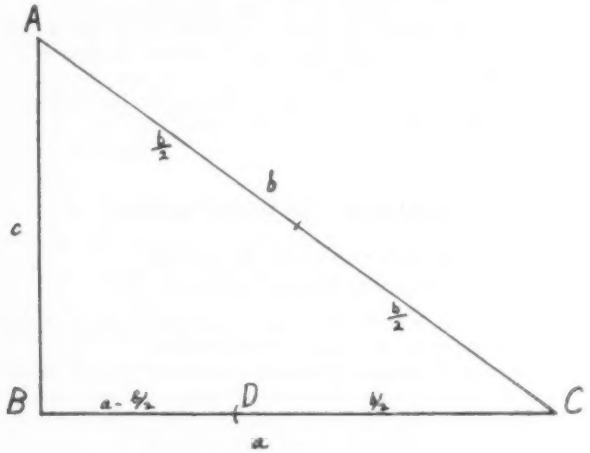
2069. *Walter R. Warne, Alton, Ill.*

2077. *Proposed by W. S. Pemberton Brookfield, Mo.*

In triangle ABC, with ange $B=90°$, with C as center and $AC/2$ as radius cut BC at D. Find the relations between AB and BC so that $BD/DC=DC/BC$.

Solution by C. W. Trigg, Los Angeles City College

Let $AB=c$, $AC=b$, $BC=a$. Then $DC=\frac{1}{2}b$ and $BD=a-\frac{1}{2}b$. Now if BD/DC



$=DC/BC$. then $\frac{1}{4}b^2=a^2-\frac{1}{2}ab$. That is, $b^2+2ab-4a^2=0$, so $b=a(\sqrt{5}-1)$. Now

$$c=\sqrt{b^2-a^2}=a\sqrt{5-2\sqrt{5}}, \quad \text{so} \quad \frac{AB}{BC}=\frac{c}{a}=\sqrt{5-2\sqrt{5}}\doteq 0.727.$$

The angle $C=36°$.

Other solutions were offered by Solomon Popler, Bradley Beach, N. J.; W. J. Cherry Berwyn, Ill.; W. A. Richards, Riverside, Ill.; W. R. Smith, Suttons Bay, Mich.; Hazel S. Wilson, Annapolis, Md.; Alan Wayne, Flushing, L. I., N. Y.; Norma Sleight, Winnetka, Ill.; Felix John, Ammendale, Md.; M. C. Corrie, Indianapolis, Ind.; Francis L. Miksa, Aurora, Ill.; Max Beberman, Nome, Alaska; Margaret Joseph, Milwaukee, Wis.; V. H. Paquet, Colton, Ore.; A. McNeish, Chicago; V. C. Bailey, Evansville, Ind.; Hugo Brandt, University of Md.

2078. *Proposed by Frederick E. Neinmers*

Prove that the line joining one focus of an ellipse with the end point of the latus rectum drawn through the other focus is greater than the semi-major axis.

Solution by Felix John, Ammendale, Md.

From the figure, by definition of an ellipse, $F_2Q_1+F_1Q_1=2a$.
Hence $F_2Q_1=2a-F_1Q_1$
But

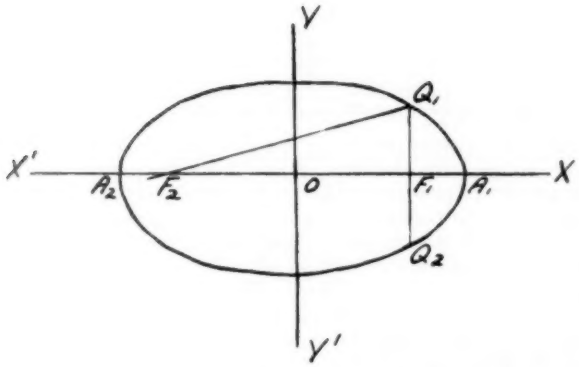
$$F_1Q_1=\frac{b^2}{a}.$$

$$F_2Q_1=2a-\frac{b^2}{a}.$$

Since in an ellipse, $b<a$, then

$$b^2<a^2, \quad \frac{b^2}{a}<a, \quad a-\frac{b^2}{a}>0, \quad \text{and} \quad 2a-\frac{b^2}{a}>a.$$

Hence, $F_2Q_1>a$.



Solutions were also offered by Hugo Brandt, Hyattsville, Md.; Alan Wayne, Flushing, L. I., N. Y.; V. C. Bailey, Evansville, Ind.; Julius S. Miller, New Orleans; Max Beberman, Nome, Alaska; S. E. Field, Ironwood, Mich.; Francis L. Miksa, Aurora, Ill.; M. C. Corrie, Indianapolis, Ind.; Francis A. C. Sevier, Philadelphia; Solomon Popler, Bradley Beach, N. J.

2079. *Proposed by Belle Conley, Newark, N. J.*

Without the use of logarithms find x, if

$$2^{x^2}:2^{2x}::8:1$$

Solution by Leonard F. Leamy, Worcester, Mass.

In any proportion the product of the means equals the product of the extremes:

$$2^{x^2}(2^{2x})=2^{x^2} \tag{1}$$

$$2^{2x+3}=2^{x^2} \tag{2}$$

$$x^2-2x-3=0 \tag{3}$$

Factoring

$$(x-3)(x+1)=0 \tag{4}$$

Whence

$$x-3=0 \quad \text{and} \quad x=3$$

$$x+1=0 \quad \text{and} \quad x=-1$$

Solutions were also offered by Norma Sleight, Winnetka, Ill.; A. MacNeish, Chicago; V. C. Bailey, Evansville, Ind.; Eugene Roberts, San Francisco; Max Beberman, Nome, Alaska; W. J. Cherry, Berwyn, Ill.; Francis L. Miksa, Aurora, Ill.; Ronald Henderson, Pine Mountain, Ky.; H. C. Welihen, Detroit; S. E. Field, Ironwood, Mich.; Hobart Boleyach, Benton Harbor, Mich.; R. T. Ashbaugh, Longmont, Colo.; M. C. Corrie, Indianapolis; Francis A. C. Sevier, Philadelphia; Donald E. Kurtz, Craig, Colo.; Oakley T. Herrell, Park Ridge, Ill.; Felix John, Ammendale, Md.; Edward F. Valdyga, Bridgeport, Conn.; J. H. Means, Austin, Texas; C. W. Trigg, Los Angeles; W. R. Smith, Suttons Bay, Mich.; Hazel S. Wilson, Annapolis, Md.; Eileen T. Tormey, Saylesville, R. I.;

Donald King, Portland, Ore.; Solomon Popler, Bradley Beach, N. J.; Alan Wayne, Flushing, L. I., N. Y.; Julius S. Miller, New Orleans.

2080. *Proposed by Anna Campbell, Geneva, N. Y.*

If a, b, c are roots of $x^3+qx+r=0$, form the equation whose roots are

$$\frac{b+c}{a^2}, \qquad \frac{c+a}{b^2}, \qquad \frac{a+b}{c^2}.$$

Solution by Alan Wayne, Flushing, L. I., N. Y.

We note that $a+b+c=0$, or $b+c=-a$, $a+b=-c$, and $a+c=-b$.

Thus we wish to form the equation whose roots are $-1/a$, $-1/b$, and $-1/c$; that is, the negative reciprocals of the given roots.

We need merely write coefficients in reverse order, and change the signs of those coefficients which are in even position in the complete equation. The desired equation is, therefore $rx^3-qx^2-1=0$.

Solutions were also offered by W. J. Cherry, Berwyn, Ill.; V. C. Bailey, Evansville, Ind.; Max Beberman, Nome, Alaska; M. Joseph, Milwaukee; Felix John, Ammendale; C. W. Trigg, Los Angeles, Hazel S. Wilson, Annapolis, Md.; Wm. A. Richards, Riverside, Ill.; Hugo Brandt, Univ. of Md.; Solomon Popler Bradley Beach, N. J.

2081. *Proposed by Norman Anning, University of Mich.*

What number must be marked in the row: 1, 2, 3, . . . , 287, 288 so that the sum of the numbers on one side of it shall equal the sum on the other side? Find the next number greater than 288 such that a similar problem can be made about it.

Solution by Francis L. Miksa Aurora Ill.

In the arithmetical progression

$$1+2+3+\cdots+(n-1)+(n)+(n+1)+\cdots+(p-1)+p \tag{1}$$

let "n" be the "marked number."

We are to seek values of n, and p such that the sum of the first $(n-1)$ terms of the progression (1) shall equal the sum of the last $(p-n)$ terms, or

$$\frac{(1+n-1)(n-1)}{2}=\frac{(n+1+p)(p-n)}{2} \tag{2}$$

$$n^2-n=p^2-n^2+p-n \tag{3}$$

$$2n^2=p^2+p. \tag{4}$$

This can be written as

$$2n^2=\frac{(2p+1)^2-1}{4} \tag{5}$$

$$(2p+1)^2-2(2n)^2=1. \tag{6}$$

Set

$$x=(2p+1) \quad \text{and} \quad y=2n. \tag{6.1}$$

Then (6) becomes

$$x^2-2y^2=1. \tag{7}$$

This is a Pellian Equation. Solution of (7) in integers is treated in nearly all books on Number Theory, see Chapter XI of Uspensky's and Heaslet's Elementary Number Theory.

The smallest solution of (7) in integers is

$$3^2-2.2^2=1, \tag{8}$$

From one solution of (8) all other can be had by

$$(3+2\sqrt{2})^m = X+Y\sqrt{2} \qquad m=1, 2, 3, \cdots \text{etc.}$$

Thus:

$$(3+2\sqrt{2})^2 = 17+12\sqrt{2}$$

Whence $n=6$; and $p=8$ by (6.1) this is the least solution involving n, and p.

$$(3+2\sqrt{2})^3 = 99+70\sqrt{2}$$

Whence $n=35$ and $p=49$.

$$(3+2\sqrt{2})^4 = 577+408\sqrt{2}$$

Whence $n=204$, and $p=288$.

This is the required solution of 2081.

To find next higher value of n and p we find.

$$(3+2\sqrt{2})^5 = 3363+2378\sqrt{2}$$

whence $n=1189$ and $p=1681$.

Thus $p=1681$ is the next number greater than 288 which admits of a solution of this problem.

Other solutions were offered by Max Beberman, Nome, Alaska; Wm. A. Richards, Riverside, Ill.; Adrian Struyk, Paterson, N. J.; Felix John, Ammendale, Md.; W. R. Smith, Suttons Bay, Mich.; C. W. Trigg, Los Angeles; Hazel S. Wilson, Annapolis, Md.; Aaron Buchman, Buffalo; Alan Wayne, Flushing, L. I., N. Y.; Hugo Brandt, Univ. of Md.

2082. *Proposed by Glendale Wallace, Stockton, Calif.*

Solve:

$$(x+1)(x+2)(x+3)(x+4)=24.$$

Solution by Leonard F. Leamy, Worcester, Mass.

Performing the indicated multiplication and combining terms:

$$x^4+10x^3+35x^2+50x=0.$$

Factoring:

$$x(x^3+10x^2+35x+50)=0 \qquad x=0.$$

The resulting cubic equation has real coefficients and its discriminant is negative so it has one real root and two conjugate imaginary roots.

Find the real root by the Factor Theorem

$$x=-5.$$

The resulting quadratic

$$x^2+5x+10=0$$

solved by the quadratic formula gives the two conjugate imaginary roots:

$$x=\frac{-5\pm\sqrt{-15}}{2}.$$

Other solutions were offered by Hugo Brandt, Univ. of Md.; Julius S. Miller, New Orleans; Norma Sleight, Winnetka, Ill.; A. MacNeish, Chicago; M. C. Corrie, Indianapolis; V. C. Bailey, Evansville, Ind.; V. H. Paquet, Colton, Ore. Max Beberman, Nome, Alaska; Margaret Joseph, Milwaukee; Francis L. Miksa, Aurora, Ill.; S. E. Field, Ironwood, Mich.; R. T. Ashbaugh, Longmont, Colo.; Francis, A. C. Sevier, Philadelphia; Felix John, Ammendale, Md.; E. F. Valdyga, Bridgeport, Conn.; Adrian Struyk, Paterson, N. J.; James Means, Austin, Texas; J. Cherry, Berwyn, Ill.; C. W. Trigg, Los Angeles; Hazel S. Wilson,

Annapolis, Md.; H. D. Hatch, Wollaston, Mass.; D. McLeod, Winnipeg, Canada; Donald D. King, Portland, Ore.; Wm. A. Richards, Riverside, Ill.; O. T. Herrell, Park Ridge, Ill.; Donald E. Kurtz, Craig, Colo.; Solomon Popler, Bradley Beach, N. J.; Alan Wayne, Flushing, L. I., N. Y.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

2072. *Mary L. King, Red Bank, N. J.*

2079. *Bernadine Banderab, Wordin, Mont.; Louis V. Tomasetti, Bloomfield, N. J.; Richard Schubert, Cicero Ill.; Barbara Brasefield, Shrewsbury, N. J.*

2082. *Robert J. Hinds, Arlington Heights, Ill.*

2079. *Robert J. Hinds, David Kurtz, Dick Morrow, and Bernard Brock—all from Arlington Heights, Ill.*

2078, 9, 80, 2. *Warren Ashcroft, Hamilton, Ontario.*

2077, 9, 82. *Robert Ojemann, Iowa City, Iowa.*

PROBLEMS FOR SOLUTION

2095. *Proposed by Charles W. Trigg Los Angeles, Calif.*

Show that in a nine-celled magic square the central element must equal one-third of the constant. (The constant is the sum of the elements of any column, row, or diagonal.)

2096. *Proposed by Roy Wild, University of Chicago*

If $\alpha+\beta+\psi=180°$, show that

$$\begin{vmatrix} \cos\alpha & \cos\beta & \cos\psi \\ \csc\alpha & \csc\beta & \csc\psi \\ \sec\alpha & \sec\beta & \sec\psi \end{vmatrix} = 0.$$

2097. *Proposed by Felix John, Ammendale, Md.*

The series of positive integers is divided into groups 1; 2, 3, 4; 5, 6, 7, 8, 9; . . . . Prove that the sum of the numbers of nth group is $(n-1)^3+n^3$.

2098. *Proposed by Francis L. Miksa, Aurora, Illinois*

Given

$$\frac{\sin(2x+y)}{\sin 2x}-\frac{\sin(2y+x)}{\sin 2y}=0.$$

Show that this equation may be resolved into the equation:

$$(\cos x-\cos y)[\cos^2 x+y)+\cos x\cos y]=0.$$

2099. *Proposed by Frank Sevier, Philadelphia, Pa.*

Find a four digit number, such that the product of the extreme digits, which are equal, is equal to the number formed by the two inner digits, the sum of these inner digits being equal to one of the extreme digits.

2100. *Proposed by Felix John, Ammendale, Md.*

In triangle ABC,

$$\frac{\cos C}{\sin A \sin B}=\frac{3-\sqrt{3}}{3},$$

also

$$\tan A \cdot \tan \cdot B \tan C=3+2\sqrt{3}.$$

Find angles A, B, and C.

BOOKS AND PAMPHLETS RECEIVED

CHEMISTRY AT Work, by William McPherson and William Edwards Henderson, both Professors of Chemistry in the Ohio State University, and George Winegar Fowler, Supervisor of Science, City Schools, Syracuse, New York. Revised Edition. Cloth. Pages x+676. 13.5×22 cm. 1948. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.88.

GENERAL MATHEMATICS IN DAILY ACTIVITIES, by Walter W. Hart, Author of Mathematics Textbooks, Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin, and M. Cottell Gregory, Teacher of Mathematics, Louisville Girls High School, Louisville, Kentucky. Cloth. Pages vii+406. 13.5×20.5 cm. 1948. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.00.

ANALYTIC GEOMETRY, by Roscoe Woods, Associate Professor of Mathematics, State University of Iowa. Revised Edition. Cloth. Pages xiv+322. 13.5×21.5 cm. 1948. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

BACTERIOLOGY—A TEXTBOOK OF MICROORGANISMS, by Fred Wilbur Tanner, Professor of Bacteriology and Head of the Department, University of Illinois, Urbana, and Fred Wilbur Tanner, Jr., Bacteriologist, Fermentation Division, Northern Regional Laboratory, Bureau of Agricultural and Industrial Chemistry, United States Department of Agriculture, Peoria, Illinois. Fourth Edition. Cloth. Pages x+625. 13.5×21.5 cm. 1948. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $4.50.

BIOLOGY AND HUMAN AFFAIRS, by John W. Ritchie. Cloth. Pages xiv+818. 14.5×22.5 cm. 1948. World Book Company, Yonkers-on-Hudson 5, New York. Price $3.40.

INTERPRETING SCIENCE SERIES, 1947 EDITION, by Franklin B. Carroll, Head, Science Department, Frankford High School, Philadelphia, Pa. Understanding Our Environment, Book I, 324 pages. 14.5×23 cm. Price $2.00. Understanding Our World, Book II, 426 pages. 14.5×23 cm. Price $2.24. Understanding the Universe, Book III, 568 pages. 14.5×23 cm. Price $2.48. The John C. Winston Company, Philadelphia, Pa.

ANALYTIC GEOMETRY, by Clyde E. Love, Ph.D., Professor of Mathematics in the University of Michigan. Fourth Edition. Cloth. Pages xi+306. 13×20.5 cm. 1948. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

FUNDAMENTAL OF STATISTICS, by J. B. Scarborough, Ph.D., United States Naval Academy, and R. B. Wagner, Ph.D., Oberlin College. Cloth. Pages vii+145. 15×23 cm. 1948. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.40.

ELEMENTARY INDUSTRIAL ELECTRONICS, by William R. Wellman, Co-Chairman, Radio Department, George Westinghouse Vocational High School, New

York City. Cloth. 384 pages. 14.5×23 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $3.20.

A PHILOSOPHY OF MATHEMATICS, by Louis O. Kattsoff, Associate Professor of Philosophy, University of North Carolina. Cloth. Pages ix+266. 15×22 cm. 1948. The Iowa State College Press, Ames, Iowa. Price $5.00.

MODERN MATHEMATICS, by S. A. Walling, Senior Master R.N. (Ret.) and J. C. Hill, B.A. (Cantab.) Education Department, Cambridge University Press. Cloth. Pages vi+153. 12.5×19.5 cm. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.00.

BASIC MATHEMATICS, A WORKBOOK, by M. Wiles Keller, Purdue University, and James H. Zant, Oklahoma Agricultural and Mechanical College. Paper. Pages v+253. 20.5×28 cm. 1948. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.50.

GUIDING PRIMARY CHILDREN WITH EMPHASIS ON PRE-READING ACTIVITIES, by Elizabeth Brown and Louise Sires, Department of Education, Iowa State Teachers College, Cedar Falls, Iowa. Paper. 36 pages. 17×25.5 cm. January, 1948. Iowa State Teachers College, Cedar Falls, Iowa. Price 20 cents.

HOW BIG IS OUR JOB, an Address by L. R. Boulware, Vice President—Employee Relations, General Electric Company.

INTERIM PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF AMERICA. Proceedings of Joint Conference of Committee on Geologic Education and Association of Geology Teachers, by M. King Hubert, Chairman. Paper. 37 pages. 15×24.5 cm.

THE RADIO AMATEUR'S BEAM POINTER GUIDE, by John F. Rider, (W2RID) Paper. 32 pages. 21.5×28 cm. 1948. John F. Rider, Publisher, Inc., 404 Fourth Avenue, New York 16, N. Y. Price $1.00.

BOOK REVIEWS

TELEVISION SIMPLIFIED, by Milton S. Kiver. Cloth. Pages vii+375. 13.5×20.5 cm. 1946. D. Van Nostrand Company, Inc., 250 Fourth Ave., New York 3, N. Y. Price $4.75.

A book for radio men and women who will design, construct and repair television sets. It will aid in bridging the gap between the modern "pure" sound receiver and the more complex television circuits. This transition is simply made in this book.

It starts out with a chapter on the television field in general, including a very interesting description of the electron beam scanning methods of the Iconoscope, Orthicon and Image Dissector transmitting tubes. This chapter makes clear how the television receiver makes use of the cathode-ray beam by blanking and synchronizing signals in order to keep in step with the transmitter. It explains the reason for wide frequency bands and high video frequencies.

Chapter II explains Ultra-High Frequency Waves and the Television Antenna. Chapter III takes up the problem of wide-band tuning circuits and R.F. amplifiers. Chapters IV–VII include discussions on each of the following topics: H.F. Oscillator, Mixer, I.F. Amplifiers, Diode Detectors and the Automatic Gain Control Circuits, Video Receivers and D.-C. Reinsertion into video signals.

Chapter VIII on Cathode-Ray Tubes is a chapter which the high school physics student could read with interest. Its description of the structure and operation of these electron beam tubes and the power supplies in television sets make it perhaps the most attractive chapter. The next three chapters are more technical and difficult. They are devoted to the synchronizing circuit funda-

mentals, deflecting systems, and the analysis and alignment of a typical television receiver.

There is a very interesting chapter on Color Television and another chapter on Frequency Modulation by which the audio portion of television is transmitted. The last chapter, on servicing television receivers should be especially interesting to radio and television repair men.

ESTIL B. VAN DORN
Indianapolis, Indiana

ADVENTURES WITH PLASTICS, by Louis V. Newkirk. Ph.D., *Director, Bureau of Industrial Arts;* Coleman Hewitt, M. A., *Chicago Teachers College;* and LaVada Zutter, M.A., *Designer and Illustrator, and Former Teacher Arts and Crafts, Chicago Public Schools.* Cloth. Pages x+275. 18×25.5 cm. 1947. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.50.

Adventures in Plastics expresses well the purpose of this book. It is an introduction to the subject of plastics through working with plastics in the school or home workshop. The methods of working plastics are clearly and logically discussed, and illustrated by large attractive pictures and diagrams. The projects are selected to appeal to interest of the students and their parents. The work progresses from the most simple projects to the more advanced ones.

Chapter I is devoted to tools and equipment. Many of these tools, and much of the equipment can be made in the school and home workshop. This chapter also describes the fundamental processes used in shaping and constructing more than one hundred beautiful pieces of plastic handicraft. The next eight chapters give instruction for making all kinds of objects, such as costume jewelry, desk gadgets, dress accessories, games, table ware, fixtures, home articles and preserving specimens. Chapter IX is very interesting in the description of preserving in plastic such specimens as stamps, coins, insects, pictures, minerals and the like. The next chapter describes the types of plastics. Chapter XI is given to the importance of plastics in industry. The appendix offers suggestions for ordering plastics and other supplies needed in laboratory work. A bibliography of books and periodicals relative to this subject will be very useful to the beginning student.

This book should be much desired in a science library and is a good reference text for the home or school workshop.

ESTIL B. VAN DORN

DAVISON'S MAMMALIAN ANATOMY WITH SPECIAL REFERENCE TO THE CAT, Revised by Frank A. Stromsten, *Associate Professor of Zoology, University of Iowa.* Seventh Edition. Cloth. Pages xi+349, 187 figures. 15×23 cm. 1947. The Blakiston Company, Philadelphia. Price $4.25.

This is a much improved edition of a widely used text book. There are 92 new figures from dissections by the author, six of which are in color. This edition resembles a good text book in human anatomy in that there are many excellent drawings of regional anatomy with structures fully labeled on the drawings. Some of the older drawings retain the time-honored but less efficient method of labeling with letters or numbers, with key legends below.

Numerous recent papers and monographs have contributed to the changes in this edition. While the work is largely a detailed anatomy of the cat, and is thus well adapted as a laboratory text to accompany dissections, it also contains much on the functions of the structures described. Comparisons are made in text and drawings between the cat and other mammals, especially man. The meaning of structure in terms of adaptation is emphasized. The Introduction contains a section on phylogeny and classification of vertebrates and one on methods of preserving material.

At the end of each chapter there is a bibliography of books and articles. A Glossary of 10 pages, giving pronunciation, derivation, and brief definitions of terms is appended. The Index (23 pages) is thoroughly subdivided; it seems to be

essentially complete. The text is set in clear and legible type; the paper is of good quality; and the binding is substantial.

EDWARD C. COLIN
Chicago Teachers College

TEXTBOOK OF GENERAL ZOOLOGY, by Winterton C. Curtis, *Professor Emeritus of Zoology, University of Missouri* and Mary J. Guthrie, *Professor of Zoology, University of Missouri*. Fourth Edition. Cloth. Pages xx+794. 524 figures. 15×23 cm. 1947. John Wiley & Sons, Inc., New York. Price $4.50.

As in its earlier editions this book combines a discussion of principles with a description of phyla. Twenty-two phyla of animals are recognized. In all but two cases the authors agree with Hyman's classification in her book on The Invertebrates; she regards the Acanthocephala as a Class and the Hemichordata as a phylum, while the present authors consider the former a phylum and the latter subphylum. The eight most commonly studied phyla—Protozoa, Coelenterata, Platyhelminthes, Mollusca, Annelida, Arthropoda, Echinodermata, and Chordata are allotted space varying from 20 pages for the flatworms to 69 pages for the arthropods. Under each phylum the usual type forms are described in some detail.

Brief discussions of ecological relationships and of the history of zoology are included at appropriate places in the various chapters. This plan seems more effective than the one of combining the material in separate chapters on ecology and the history of zoology, as is sometimes done. A separate chapter is devoted to a comparison of the organ-systems of invertebrates. The book concludes with a long chapter (82 pp.) on The Evolution of Animal Life. This chapter combined with the first six dealing with principles of vertebrate organ-systems, the cell, reproduction, embryonic development, and genetics accounts for 40% of the volume.

The book is notable for the numerous excellent figures, many of which are original or redrawn and clearly labeled directly on the figures rather than by the older less efficient method of letters and key legends. There is a Glossary of 21 pages and an Index of 48 pages. The index suffers from inconsistency in subdivision. For example, the term *anus* is followed by 78 page numbers with no subentries, while *mouth*, with 79 entries, is subdivided by animal groups into 12 divisions. The above is an extreme case, but there are other terms such as ectoderm, eggs, embryo, endoderm, fertilization, gills, intestine, ovary, spermatozoa, tentacles, and zygote followed by long lists of page numbers without subdivisions.

As a whole the book contains much useful information and discussion, clearly presented for the college student. It is printed in clean and legible type on a good grade of paper and is well bound in cloth.

EDWARD C. COLIN

BASIC BIOLOGY, by Carroll Lane Fenton, Ph.D., and Paul E. Kambly, Ph.D., *Professor of Education and Director of Supervised Teaching, University of Oregon*. Cloth. Pages ix+726. 13.5×17 cm. 1947. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.24.

This text attempts to present the story of life in eleven basic units, which in turn are broken up into specific chapter headings. The authors seek to explain in their text the broad fundamental principles of life and to relate these in so far as possible to man. They state in their introduction that the text is not designed to make a scientist of the student, but simply to introduce him to scientific thinking and to scientific methods of work.

The unit titles are as follows: I—Living Things and Their World; II—The Make-up of Organisms; III—Groups and Kinds of Organisms; IV—Foods for the Living Worlds; V—Feeding the Animal Kingdom; VI—Organs, Systems, and Health; VII—Producing New Organisms; VIII—Old Characters and New Ones; IX—How Living Things Have Changed; X—Communities and Control; XI—Using the World We Live In.

The book is well illustrated with an unusually large number of original photographs, and line drawings of excellent quality. Indeed these form an important teaching feature of the book. A series of objective tests, questions and projects included at the end of each chapter will be useful to both students and instructor.

Chief criticisms of the text are insufficient explanation of the text figures and an inadequate amount of subject matter needed to develop the principles to be taught. It is very unfortunate that, whereas other systems of the human body have been well treated, practically no attention has been given to the human reproductive system. High school students are left to obtain this information from less reliable sources.

HILMER C. NELSON
Wilson Branch
Chicago City Junior College

ENERGY UNLIMITED. The Electron and Atom in Everyday Life, by Harry M. Davis, *Science Editor of Newsweek*. Cloth. Pages xiv+273. 14×21 cm. 1947. Murray Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $4.00.

This is a book for the science teacher and alert man or woman who wants to know about the new things in science. It is clearly written in language easily understood by one with an ordinary education. It is well illustrated by pictures of scientists and their work. Forty-eight full pages of illustrations with good description are grouped in three sections. The chapters are short and each is a complete story so that one may begin reading any place in the book. Here are a few of the chapter headings: The *A B C* of Atoms, The New Art of Electronics, The Electron Microscope, Radar at Work, Television, The Electronic Attack on the Atoms, Atomic Bombs, Today's Sources of Energy, Tomorrow's Sources of Energy.

G. W. W.

ELEMENTARY ARITHMETIC ITS MEANING AND PRACTICE, by Burdette R. Buckingham. Cloth. Pages viii+744. 15×23 cm. 1947. Ginn and Company, Statler Building, Boston 17, Mass. Price $4.50.

Occasionally one is asked to review a book which is so different from other books bearing similar names that it is difficult to write a review. In examining *Elementary Arithmetic* your reviewer was convinced that here is such a book. The author says in the preface that "the object" (of this book) "is to help the student not merely to develop (or to regain) facility in computing but also to attain a measure of insight into the meaning and significance of what he does." The book is directed to college students who are planning to teach in the elementary schools and is intended not only to review elementary arithmetic but also to give the student a background so that as a teacher he may make this subject more interesting for his or her students.

The book is divided into twenty chapters. These include the following topics: Idea of Number; Our System of Notation; Number Concepts; The Operations of Arithmetic; Addition, Subtraction, Multiplication and Division of Whole Numbers; Common and Decimal Fractions; Percentage; Universal Arithmetic; Measurement; Scaling and Graphing: Measuring Angles and Arcs; Volume, Capacity, Weight and Time; and finally The Metric System. As may be seen by examining this list the book includes many topics usually left out of elementary arithmetic books. The development of arithmetic through the development of our number system, and its progress and use in various ways make this book not only informative as to arithmetic processes but also interesting as reading material.

The book is very interesting and is well written. At the close of each chapter, there is a summary of the chapter. This is followed by a number of questions and problems, which provide a yardstick for measuring one's understanding of the work just completed. Although one should keep in mind that this book is in-

tended primarily for students who plan to become elementary teachers, it is also true that the book contains excellent material for more advanced students and for teachers who are interested in making arithmetic more meaningful and more interesting.

ALBERT R. MAHIN
Broad Ripple High School
Indianapolis, Indiana

MATHEMATICS OF BUSINESS AND ACCOUNTING, by Kenneth Lewis Tefftzs, Ph.D., *Associate Professor Finance, University of Southern California* and E. Justin Hills, Ph.D., *Department of Mathematics, Los Angeles City College*, Cloth. Pages xii+267+51. 15×23.5 cm. 1947. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.00.

This is a textbook for use in colleges or business courses. There are three principal sections: first, a section in which there is a comprehensive review of the operations of arithmetic; second, a review of the fundamental principles of algebra; and third, applications of the other two sections to business practices and procedures. The examples are good and the number of exercises is large enough that provision can be made for individual differences.

The book is written so that certain sections can be either studied or omitted, at the discretion of the teacher. One such section discusses exponents, logarithms, and the slide rule, another discusses trade discounts, mark ups, and mark downs, a third discusses annuities, and a fourth discusses annuity principles. The appendix includes a six place logarithm table and representative tables from the complete tables published under the title "Financial Compound Interest and Annuity Tables" by the Financial Publishing Co.

Though your reviewer is not a college teacher of business mathematics, this book seems to him to include many of the fundamentals which should be included in such a course. It should definitely be considered by those who plan to adopt business mathematics textbooks for college or business schools.

ALBERT R. MAHIN

TIME, KNOWLEDGE, AND THE NEBULAE, by Martin Johnson, *Birmingham University, Birmingham, England.* With a foreword by E. A. Milne. Cloth. Pages 189. 14×21.5 cm. 1947. Dover Publications, New York. Price, $2.75.

This book is well described by its subtitle: "An introduction to the meanings of Time in physics, astronomy, and philosophy, and the relativities of Einstein and of Milne." It should be noted that the word "meanings" is the plural form. Much of the book is concerned with pointing out that there is more than one meaning that can be ascribed to time, and with the consequences of the graduation of clocks according to the scheme proposed by Milne. It is shown, for instance, that the famous red shift of spectral lines from distant nebulae arises not because of a hypothetical recession of the source (the "expanding universe") but because of a change in the frequency of the atoms of the receiver during the interval of transit of the light from the source.

The book begins with a discussion of the need for reconsideration of physical notions of time, continues with a treatment of the Lorentz-Einstein space-time concept, and concludes with a critique of arguments involving time in physical and mental science, in metaphysics, and in theory of scientific knowledge. It is written for the intelligent layman, for whom an appendix provides some background of physics and the history of theories of relativity. But even the intelligent layman will find that he cannot read the book easily, because of the unfamiliarity of the ideas and closeness of the argument. Yet the reader who is willing to go slowly and thoughtfully will find the treatment exceedingly stimulating, and will emerge with at least some increase in his understanding of the meaning of relativity, a realization of the fact that the Einstein theory is by no means the last word, and a clearer view of the fundamental importance of the concept of time in all of science.

The book is written with great clarity, is well made, and in view of the times is offered at a very low price.

JOSEPH D. ELDER
Wabash College

ELEMENTARY DIFFERENTIAL EQUATIONS, by Lyman M. Kells, Ph.D., *Professor of Mathematics at the U. S. Naval Academy*. Third Edition, cloth. Pages xiv+312. 14.5×20.5 cm. 1947. McGraw-Hill Book Company, Incorporated, New York, N. Y. Price $3.

This is the Third Edition of a college text which has met with considerable approval. Although the author states that practically every article of the book has been revised, this is perhaps somewhat over optimistic. Many of the problems are identical with those of the Second Edition.

The emphasis is more upon application than theory. The material includes a chapter on solution by series and approximation methods and three chapters on partial differential equations. As contrasted with the Second Edition, material on components of velocity and the hodograph has been practically eliminated. The material on practical problems of electricity has been reorganized and expanded.

The book has proved to be exceptionally teachable; a few misprints occurring in earlier editions have been corrected. Unfortunately, some errors still remain. Pages 94 and 95 show some particularly poor typography, particularly with respect to exponents. There is an obvious mis-print on page 110 where e^x appears as ex. Unfortunately, some of the answers were apparently not carefully considered. Sometimes a particular solution is given where a general solution was asked for, or vice versa. Again approximate answers are sometimes given without an indication that they were not intended to be exact.

The objections mentioned are quite minor. Anyone wishing a text for a first course in differential equations should by all means consider this book.

CECIL B. READ
University of Wichita

COLLEGE, ALGEBRA, by H. A. Simmons, *Associate Professor of Mathematics, Northwestern University*. Cloth. Pages viii+619. 14×21.5 cm. 1948. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

This book is planned to cover the content of the courses customarily known as intermediate algebra and college algebra. The material included is more extensive than in some texts, for example the treatment of perpetuities, the use of derivatives of polynomials, and the development of the tangent line to a curve at a given point (an obvious omission in a formula on page 276 occurs in this connection). In common with many texts the erroneous statement is made that logarithms of two numbers having the same sequence of digits have a common mantissa, when the statement should be restricted to logarithms to the base 10. Figure 75 on page 483 is poorly drawn.

The criticisms just mentioned are relatively minor ones. The book has some excellent features. There is a chapter of 21 pages on the use of the slide rule which includes definitions of the trigonometric functions. A particularly good, although unusual feature, is the treatment of admissible values of x which can appear in an expression. More material is included than would normally be taught in one semester of either course. In general, there is an ample supply of problems, although in a few sections the number of problems is hardly adequate to provide alternate assignments in successive semesters. Certain starred sections can be omitted without breaking the continuity of the course. On page 5 one finds a footnote indicating that a particular problem may be thus omitted. This would imply that other problems could not be omitted without disturbing the continuity, but casual examination would indicate that this is not the fact.

Tables included are powers and roots; four-place common logarithms; com-

pound amount; present value; present value and amount of an annuity; trigonometric functions; and the American Experience Tables of Mortality. Answers are provided to the odd-numbered problems. Other answers are available.

CECIL B. READ

NOMOGRAPHY, by A. S. Levens, M.S., C.E., *Associate Professor of Mechanical Engineering, University of California*, Berkeley, Calif. Cloth. Pages viii+176. 14.5×23 cm. 1948. John Wiley and Sons, Inc., 440 Fourth Avenue. New York 16, N. Y. Price $3.00.

The treatment of this text is primarily for the person interested in designing and using nomograms rather than for the individual interested in the development of underlying theory. Emphasis is placed on what the author terms the geometric method, with only a brief chapter on the treatment by means of determinants. After some brief introductory material the chapters take up alignment charts under seven major types. The method of constructing such charts is discussed in detail. The illustrative examples are treated more completely than is true in many texts.

The mathematics involved does not require anything beyond college algebra. For the purpose in mind the treatment seems very good. There is an ample supply of exercises, and in the Appendix there are twenty-nine well drawn examples of alignment charts, with a special index to these charts.

This book could well serve as a text for a one-semester course open to students in various fields and would not require any special mathematical background, although experience with handling mathematical formulas would be essential. It would also be a very valuable reference book in an engineering library or for that matter in any junior college which handles pre-engineering mathematics.

CECIL B. READ

HEALTH AND FITNESS, by Florence L. Meredith. B.Sc., M.D., *Professor of Hygiene and Public Health, Tufts College*. Cloth. Pages x+325. 18.5 cm.×23 cm. 1946. D. C. Heath & Co., Boston. Price $2.20.

This book is written as a text for high school students. The author's preface is one of the finest and most practical a book could have. Not only what the student wants, but also his basic needs were considered when the author selected her material.

The eight units are divided into a total of forty-five short chapters. Each chapter is from four to ten pages long with a well prepared list of Study Guide questions at the close of each for discussion purposes. The illustrations are very good and in plentiful numbers. Material for Unit seven—Mental Health—was well chosen. The chapter on "Choosing A Mate" is outstanding.

The amount of text material is probably adequate for the average freshman or sophomore, but supplementary health material would probably be needed if used in Junior or Senior classes. The paper and print are very good. The two columns of print on each page are very acceptable to some teachers, while others would have preferred a single column, narrower, page.

H. KEITH CADY
Oak Park Township H. S.
Oak Park, Illinois

OUR EARTH, by Gertrude Whipple, *Supervisor of Reading, Detroit Public Schools and Associate Professor of Education, Wayne University*, and Preston E. James, *Professor of Geography, Syracuse University*. Cloth. Pages x+245. 23.5×17.5 cm. 130 illustrations in color. 1947. The Macmillan Company, Chicago 16, Illinois. List price $1.88.

This third grade text in the *Basal Geographies* series, is a collection of stories in which mountains, hills and plains, lakes, rivers and the sea furnish a geographic setting. The stories are the sort a third grade child can read and enjoy.

They deal with people and places, and lay a foundation for the later study of geography.

The book is beautifully illustrated with pictures and maps in full color. Thirty-five of the pictures are full page illustrations. All pictures are from original kodachromes made especially for this text. They add greatly to the value and attractiveness of the book.

VILLA B. SMITH
John Hay High School
Cleveland Ohio

USING OUR EARTH, by Gertrude Whipple, *Supervisor of Reading, Detroit Public Schools and Associate Professor of Education, Wayne University*, and Preston E. James, *Professor of Geography, Syracuse University*. Cloth. Pages vii+296. 23.5×17.5 cm. 123 illustrations in color—photographs and maps. 1947. The Macmillan Company, Chicago 16, Illinois. List price $2.20.

This fourth grade text is attractively illustrated with colored photographs, many of which are full page illustrations. Each unit shows that man's adjustments to conditions in a given area have changed with the years, and that the present is related to the past and can be explained by it.

The unit, "Salmon Fishing in Early Times and Today," affords opportunity to contrast the ways of the Indians with those of the white man, and to understand why the salmon supply has been depleted and why there is need today for conservation. The unit, "How Men Changed the Pasture Lands," likewise traces the changes from the days of wild animals on the plains, to those of cowboys and their herds, to the present day cattle ranch.

"How We Came to Have Blue-Grass Farms," "Making a Woodland into Farmland," "Changing a Desert to Orchard Land," "Making Roads Across Our Country," "How a Railroad Changed a Town," are some of the other units in which the present is made more meaningful because of an understanding of the past. Throughout the book good changes and harmful changes are discussed and the need for conservation emphasized.

In the concluding unit, "The World We Live In," simple globe-maps and flat surface maps are presented. By the help of globe-maps, such phenomena as day and night and seasons are explained.

The text lays a foundation for later geography, and creates an interest which will carry over into the more formal study. It is as the series indicates, a *Basal Geography*.

VILLA B. SMITH

LOUIS AGASSIZ, SCIENTIST AND TEACHER, by James David Teller. Paper. Pages xi+145. 15×23 cm. 1947. The Ohio State University Press, Columbus, Ohio.

This is the second number of the Education Series of the Graduate School Studies of Ohio State University. It is a great biography of a great naturalist and teacher written on the centennial of Agassiz' coming to America.

The author gives one who reads this biography a feeling that he shares with the author a deep appreciation for the many contributions to scientific education. Louis Agassiz was one of those rare men who combined ability for research in science with the power of inspiring others to become great scientists and teachers.

His heritage with respect to such great men as Linnaeus, Werner, von Humboldt, Cuvier, Lamarck, Darwin and many others had a profound influence on Agassiz' early interest in science study.

This story abounds with interesting incidents in the life of Agassiz. Above all things, his greatest teacher was Nature herself. He became the greatest authority of his day on marine zoology, and he discovered many new facts about geology and animal life. The vigorous and dynamic enthusiasm and imagination that he possessed was passed on to his pupils. Many pages are devoted to his experiences in the mountains, the classroom, the laboratory, the museum, the woods, the seashore, the outdoor summer school and the public lecture hall.

His method of teaching was not always pleasing to his pupils. He did not want his pupils to get knowledge in science out of books. He insists that they observe and compare observations in the field of nature first hand. Those who had patience to follow his instructions became great teachers and great leaders in scientific education.

This dominating influence on great educational leaders is well illustrated by the author. It is a biography that high school boys and girls should read. Its sympathetic but accurate account of the life of so great a scientist is an inspiration to any one who loves nature.

ESTIL B. VAN DORN
George Washington High School
Indianapolis, Indiana

EXPERIENTIAL PHYSICS, by H. Clyde Krenerick, *North Division High School*, Milwaukee, Wisconsin. Paper. Pages 215. 15×23 cm. 1947. Price $1.00.

This text is the result of the author's rich experience as a physics teacher. Its simplicity of content, purpose, method, form of record, and philosophy make it adaptable for one period class use.

Content:

A large number of the experiments can be performed with apparatus found in the average physics laboratory. With the addition of a number of home made pieces, a large number of the experiments are available without a very great expense for apparatus. Eighty-seven experiments are offered to introduce practically all of the fundamental principles of the elementary physics course.

Purpose:

To teach the principles of physics through student laboratory experiences rather than experiments. Individual work emphasized. To present a problem or experience which can be completed in a single laboratory period of forty-five minutes. To prevent mechanical performance and discourage copy work from a text or from an older work book. To aid beginning teachers or teachers with large classes.

Method:

All laboratory work precedes all class discussions. The student must prepare his lesson before beginning the laboratory work. The text contains no formulas for mechanical substitution which makes it necessary for the student to accomplish his task through his own individual thinking. Pictures of apparatus in each experiment are supplied to aid in interpreting written instruction. This text can be used with or without other physics references.

Form of record:

It is simplified so that work must be finished in laboratory time and written up without reference to other texts or work done by another student. It makes possible quick inspection of the work done by the instructor during the closing minutes of the period. An Index Folder provides a running record of the student's work and credits.

Philosophy:

The value of any mental activity is largely in proportion to the amount of initiative required on the part of the student. Individual effort is more effective than classroom lectures and observed lecture-table demonstrations. Not how much ground is covered but how well is the work done. Learn to do by doing.

The price of the book is one dollar. It is a convenient size to carry with other books.

ESTIL B. VAN DORN

In these sweet June days
The teacher and the scholar trust
Their parting feet to separate ways.
—*J. G. Whittier*